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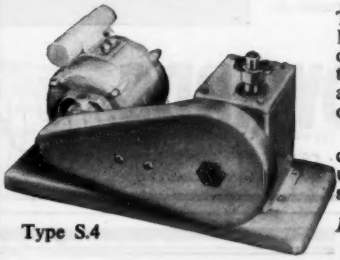

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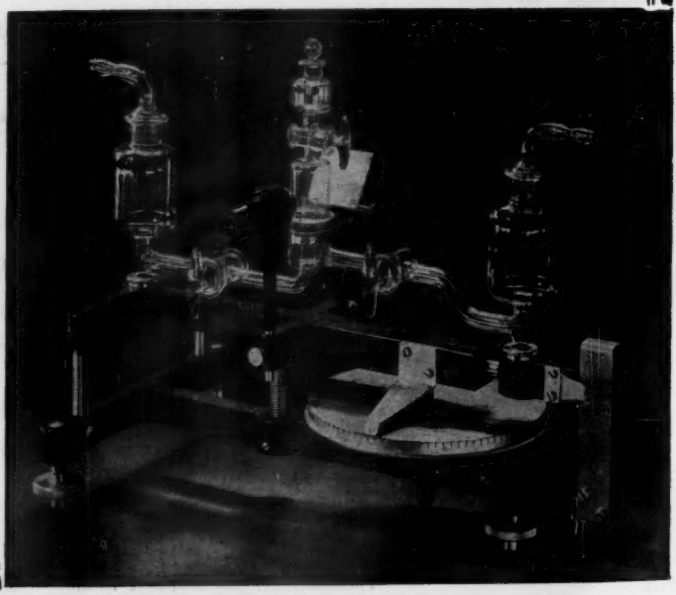

NATURE

No. 4456 SATURDAY, MARCH 26, 1955 Vol. 175

CONTENTS

	Page
Interpretation of Scientific Progress	521
Prehistory of Africa. By Abbé H. Breuil	523
Connective Tissue. By Dr. G. H. Bourne	524
Geological History of California. By Dr. W. E. Swinton	525
Instability of the Earth's Axis of Rotation. By T. Gold	526
Scientific Intelligence and Defence. By Chapman Pincher	529
Obituaries:	
Sir Edward Mellanby, G.B.E., K.C.B., F.R.S. By Prof. B. S. Platt, C.M.G.	530
Prof. J. K. Parnas. By Dr. T. Mann, F.R.S.	532
New Fellows of the Royal Society	533
News and Views	534
Organization of Applied Research. By Dr. D. W. Hill	538
Aeration in Industrial Fermentations	539
Trend and Pattern of Fertility in Great Britain	540
National Research Development Corporation: Report for 1953–54	541
Central Laboratories for Scientific and Industrial Research, Hyderabad: Report for 1953	542
Imperial College of Science and Technology, London: Report for 1953–54	542
A Simple Method for studying and demonstrating the Energy Consumption in Flying Insects. By Dr. Olavi Sotavalta	543
Resistivity in Metals. By H. G. van Bueren and P. Jongenburger; P. Jongenburger	544
Induction Periods and Ignition Limits in Sensitized Ignitions of Hydrogen and Oxygen. By Prof. R. G. W. Norrish, F.R.S., Dr. P. G. Ashmore and Prof. F. S. Dainton	546
Letters to the Editors:	
Cephalosporin C, a New Antibiotic containing Sulphur and D-α-Aminoadipic Acid.—G. G. F. Newton and Dr. E. P. Abraham	548
An Infectious Nucleoprotein from Tobacco Mosaic Virus.—By Prof. G. Schramm, G. Schumacher and W. Zillig	549
Cellular Control in Virus Infection.—Prof. P. M. de Burgh and J. F. A. P. Miller	550
A Mechanism for Citrate Dissimilation.—S. Dagley and Dr. E. A. Dawes	550
Production of Pyruvate from 6-Phosphogluconate by Bacterial Plant Pathogens and Legume Bacteria.—H. Katznelson	551
Inhibiting Effect of Trypan Blue on the Experimental Production of Liver Cancer.—S. Iwase and K. Fujita	552
Determination of the Life of Human Blood Platelets using Labelled Diisopropylfluorophosphonate.—C. H. W. Leeksma and Dr. J. A. Cohen	552
Plant Hyperplasia Induced with a Cell-free Insect Extract.—Donald Leatherdale	553
Colloid Osmotic Pressures of Dextran, Serum and Dextran–Serum Mixtures.—D. S. Rowe	554
Separation of Flavins by Ion-Exchange Resins.—K. Yagi, J. Okuda and Y. Matsuoka	555
Circular Chromatography of Terpenes on Adsorbent Coated Glass.—L. H. Bryant	556
Inverted Rhythmic Precipitation.—Dr. A. Packter	556
Intensity Variation in Sunspots.—William A. Miller	557
Germanium in Power Station Boiler Plant.—Dr. J. S. Forrest, A. C. Smith and J. M. Ward	558
Longitudinal and Screw Vibrations of Beams.—Prof. G. J. Kynch	559
An Interferometer for 'Straightness' Measurement.—J. Dyson	559
Effect of Time of Embryo Formation on Quantitative Characters in *Drosophila*.—Dr. Alan Durrant	560
The Covering Reaction in a Tropical Sea Urchin.—Prof. N. Millott	561
Breeding Systems and Compatibility in *Glyceria*.—Martin Borrill	561
Arginase in Elasmobranch Muscle.—J. J. Connell	562
Recent Scientific and Technical Books	Supp. viii

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INTERPRETATION OF SCIENTIFIC PROGRESS

As has already been noted in these columns (*Nature*, March 12, p. 439), Dr. J. H. Hildebrand's recent address to the American Philosophical Society puts both the social responsibility of the scientist and the question of security in their proper perspective as involving problems in communication and in human relations. While, however, those problems of human relations have been discussed comparatively fully—for example, in such books as those of Prof. W. Gellhorn, Alan Barth and Prof. H. S. Commager, and in relation to particular individuals like Dr. J. R. Oppenheimer, Dr. A. V. Astin and Prof. Owen Lattimore—the problems of communication have received nothing like adequate attention. Such problems, however, have a vital bearing on the success of any security programme based on those positive conceptions of security which are expressed in the recent statement from the American Association for the Advancement of Science.

This problem of communication has been discussed from slightly different aspects in three recent addresses: in H. L. Dryden's talk on the scientist in contemporary life before the Cosmos Club, Washington, on November 16; in Dr. J. R. Oppenheimer's address at the concluding celebrations of the bicentenary of the founding of Columbia University on December 26; and in the public lecture on "Science and Citizenship" which Dr. Eric James delivered at the annual meeting of the Science Masters' Association on December 29. All three addresses were concerned with the isolation of the scientist from the community and the way in which effective communication could be established, thus eliminating the dangers which this isolation threatens both in defence and in the effective application of science to national welfare and development.

Dr. Oppenheimer's address was ostensibly on what had been chosen as the main theme of the Columbia University anniversary celebrations of the past year, namely, "Man's Right to Knowledge and the Free Use Thereof"; but he dealt more specifically with the prospect in the arts and sciences, and above all he emphasized the isolation of the specialist from the broad path of human knowledge and intercourse. With more means of communication than ever before, we can speak to each other less easily and less effectively. While more people are engaged in scientific research to-day, more books are published per head in Britain than in the United States, the social sciences are pursued actively in America, Scandinavia and Britain, and more people both hear and compose music and paint, the frontiers of science are now separated by long years of study, by specialized vocabularies, arts, techniques and knowledge from the common heritage even of the most civilized society. The artist, too, finds it increasingly difficult to achieve the community of experience, and common ways of describing it and interpreting it. The common sensibility and culture, the traditions and the history, the myths and the common experience which it is his function to illuminate and to harmonize and to portray have been dissolved in a changing world.

Dr. Oppenheimer thus emphasized not simply the isolation of the scientist working at the frontier of science, but also showed that the artist and other creative workers are equally involved in this isolation. Moreover, he recognized the inevitability of the specialization of science, just as frankly as he admitted that these are heroic days in the natural sciences and likely to remain so. He emphasized also the dangers that arise when so much that is beautiful and enlightening, as in the experience of the artist, is cut off from the rest of the world. What is new, he insisted, is that in one generation our knowledge of the natural world has engulfed, upset and complemented all previous knowledge of the natural world. Our techniques of communication and production and multiplication are new. So are also the global quality of the world, our knowledge and sympathy with remote and diverse peoples, our practical involvement with them and our commitment to them in terms of brotherhood. In this world in which we have come to live, the massive character of the dissolution and corruption of authority in belief, in ritual and in temporal order are also new.

The difficulties which face us are thus derived from the growth of skill, of power, and of our understanding of that world, if not of the conditions which govern their exercise. To assail such changes is futile: we need to recognize them and to take account of our resources; nor does Dr. Oppenheimer appear to put high among such resources the mass media of radio and television, the cinema, best-seller or the world tours of successful theatrical productions. Although art and science may be purveyed by such means, they have also an inhumanizing influence and can easily destroy the individual sense of beauty.

Dr. Oppenheimer concluded this address with a plea to keep our minds open and to keep them deep, to retain our sense of beauty and our occasional ability to see it in places which may be remote and strange and unfamiliar. This, he recognized, will be no easy task; but it is the condition of man and in this condition we can help because we can love one another. On that note he closed, and not with the emphasis on the open house, with no doors and no locks, of which he spoke in his Reith Lectures a year earlier. The open access to knowledge may still be recognized as a fundamental freedom and as one barely compatible with modern political tyranny; but there is less confidence in our ability to achieve the harmony between knowledge in the sense of science and the community of man. The secrecy—the bonds of man's own making—threatens the open society, the unrestricted access to knowledge, the unplanned and uninhibited association of men for its furtherance, and thereby the possibility of making a human community out of the complex, ever-growing and ever-changing, ever more specialized and expert technological world.

The brotherhood or community of which Dr. Oppenheimer spoke rests on understanding, and here Dr. Dryden strikes the same note. Science, he points out, has made major contributions to our spiritual life as well as provided powerful tools for shaping our physical environment. It places a high premium on intellectual honesty and on objective truth, and the successes of science and their impact on every aspect of life have captured the imagination and loyalties of many men as the only guide to truth.

Nevertheless, science is only a partial view of life—in many respects a narrow view—and the consequences of failure to understand this can be the more serious in that science is also amoral. Dr. Dryden believes with A. H. Compton that our hope for the future rests in a growing understanding of the conditions for the good life of man in a world of science and technology, and the acceptance of a morality that is consistent with these conditions. It is not sufficient, however, for scientists themselves to recognize all this, and to realize their own limitations, as well as their responsibilities for the proper use of science for human welfare. These responsibilities are, in fact, the same as those of other citizens, no more, no less; and it is imperative that those responsible for the leadership of the community should be capable both of integrating the specialized knowledge which is involved in matters of public policy and also of maintaining high moral and spiritual standards.

Dr. Dryden was concerned particularly with this last factor, neglect of which, for example, in the Oppenheimer case and in the case of the U.S. Bureau of Standards and the battery additive, he regarded as primarily responsible for the discord between scientists and the Government in the United States; he believes this to be much more serious in its effects than the failure of the Government to appreciate the importance of fundamental research as the basis of progress even in applied research and to provide for generous and continuous support. Once again, it is a matter of public understanding, of the understanding of the scientist by his fellow citizens, as well as of the understanding by the scientist of those public responsibilities of which Dr. Eric James spoke. Moreover, in pleading for an increasing recognition of the social and moral responsibilities, Dr. James was not at issue with Prof. A. V. Hill's view that there is no such thing as 'the scientific mind', but that, like all good citizens, scientists must take account of ethical considerations. Dr. James was pleading rather for less complacency over present methods of education and for a more deliberate attempt to devise a system of scientific education that would produce the citizen, the Civil servant or the statesman at least as capable as those produced by the Oxford 'Greats' course.

Dr. James thinks that the means of mass communication alone, the radio and television, tend to create an uncritical, acquiescent public. This in itself threatens active citizenship and makes it accordingly the more important that the scientist and, it might be added, all those holding administrative responsibilities in government, should endeavour to disseminate information in such a way that the ordinary educated man or woman is able to understand the social and political implications of scientific knowledge. Merely to enumerate some of the major topics discussed in Parliament this session would demonstrate the extent to which wise political decisions in public policy turn on an understanding of scientific and technical issues. In matters of road and rail transport, defence, atmospheric pollution, or nuclear power, neglect of scientific and technical factors could be disastrous. Although they are not the critical factors, at least it can be said that any policy which neglects or disregards them for some purely political party prejudice will endanger the national welfare, if not, indeed, national security.

Ignoring for the moment the extent to which the question of general education at the secondary or even the primary level is involved, we are concerned with the gradual spread of knowledge in the community through the improvement of means of communication and the disappearance of obstacles to their full employment. Dr. Vannevar Bush recently spoke on these matters to the American Society of Mechanical Engineers. There is, of course, implied in that hope the assumption that with such knowledge will come true wisdom; and whether that assumption can wisely be made depends at least in part on the means of communication. That may well bring us right back to Dr. Oppenheimer's Reith Lectures.

In his book on "The Crisis in the University", Sir Walter Moberly rightly said that we need not only discoverers of facts hitherto unknown but also explorers of ideas and rethinkers of values. We are concerned with the improvement as well as the extension of knowledge, and we need more thinking about the importance of things already known. Books which throw new light on the significance and interrelations of facts already known perform a function no less important than works of research in a narrower and more technical sense. They help us to get closer to the heart of things and sometimes give a new meaning to familiar objects.

The most successful of the Reith Lectures have been those which have done exactly that. Instituted in 1948, these Lectures were intended to provide an opportunity for some acknowledged authority to give listeners, in a series of some half-dozen half-hour talks, the results of study or research on some chosen theme. It was hoped that such a series of serious talks would add to the pool of knowledge and stimulate thought as well as widen public understanding. That this hope was soundly based is to be seen from the discussion which broke out last year over Dr. Oppenheimer's lectures, "Science and the Common Understanding"*. The Reith Lectures were rightly seen as a problem in communication, though on a vaster scale than that of the serious lecture of earlier generations. When it was argued that Dr. Oppenheimer's talks had failed to make any real impact on the ordinary listener, the question was promptly raised whether this was merely an illus-

* Science and the Common Understanding. By J. Robert Oppenheimer. (The B.B.C. Reith Lectures, 1953.) Pp. vii+127. (London: Oxford University Press, 1954.) 10s. 6d. net.

tration of the common failure of communication between the physical scientist and the layman to-day, or whether something more was involved.

In so far as there was failure of communication, it is clear from the published lectures that the responsibility lies on our system of education as much as on the scientist. The lecturer is inevitably limited by the listener's own understanding of science, and failure to grasp Dr. Oppenheimer's message is in part a consequence of our neglect to ensure that those leaving our schools to-day have a general understanding of what science is and the part it plays in the world in which they have to live. That, incidentally, is a further reminder of the seriousness for the community of the continuing scarcity of science teachers in the schools, quite apart from its effect on the supply of scientists and the technologists themselves.

What emerges, however, from the discussion provoked by these particular Reith Lectures is not simply the importance of a wider public understanding of science, or of scientists taking more care in this matter of communication: it is the limitations of the specialist as expositor. Despite Dr. Oppenheimer's intense and wide human sympathies, when he moved outside the sphere of his own special competence he tended to become trite and commonplace. Prof. Hill's argument that scientists for the most part are quite ordinary folk outside their own special field was well illustrated. The task of exposition, in fact, demands not simply knowledge but also special gifts of a high order that are not commonly found. To discover such expositors and to give them full opportunity is of vital importance to the community to-day. This is not simply a matter of giving the expositor his due status, though that could be one factor in encouraging the development of such gifts. The linking of exposition and authority is perhaps one of the most important functions of such a series of lectures as the Reith Lectures, and it is one to which universities could well give more thought in arranging their extra-mural lectures and in encouraging the production of such works as Sir Walter Moberly suggested. Nor is it a matter for the universities alone: professional institutions have their own responsibilities in promoting public understanding of the issues involved in the impact upon public affairs of the technologies with which such institutions may be concerned.

The questions of professional discipline involved in the issue of exposition and authority, such as terminology or the relations between one discipline or technology and another, are only one facet of this problem of communication and public understanding. Exposition and interpretation are conditioned also by the medium of communication involved, and we cannot ignore the fact that the use of particular media or changes in political and social conditions may hinder the task of exposition or even make it impossible. There are limits to the use of broadcasting, and the potentialities of television are largely unexplored. At the same time there is real danger that they, and particularly television, may be encouraging an uncritical and unreflective passivity in listener and viewer that may also largely destroy the possibility of influencing them by the printed word.

Quite apart from this danger of a new form of illiteracy, effective communication depends not only on the existence of competent expositors and interpreters, but also on the general level of education in the community. Education cannot be dismissed as something concerned solely with fitting the school-leaver for some particular occupation or vocation: it is concerned first and foremost with enabling him to live wisely and intelligently in this age of science and technology. For that reason alone, the scientist or technologist has a special concern, as an ordinary citizen, with the standard of general education.

There is a further reason why the scientist and technologist are specially concerned with this question of communication—with the problem of interpreting clearly and effectively to the whole community the implications of scientific progress for public policy. Unless there is public understanding as to what science is doing, and the conditions of scientific and technological advance, there is real danger both that adequate financial support will not be forthcoming and policies may be pursued which threaten particular fields of scientific endeavour, possibly of vital import for the public welfare, and the conduct of scientific or other creative activity. It is increasingly important for the specialist to take care over his terminology and bear in mind the needs, not only of his fellow specialists, but also of those other scientists and technologists with whom he may be called upon to co-operate; and he should also consider the problem of interpretation to the general community. Serious thought and a determined effort are required from scientist and layman alike to solve this problem of interpreting to the ordinary citizen what science is doing, the conditions essential for effective scientific work, and the relevance to national welfare of the work and results which to-day in increasing measure are supported by public funds.

PREHISTORY OF AFRICA

The Prehistoric Cultures of the Horn of Africa

An Analysis of the Stone Age Cultural and Climatic Succession in the Somalilands and Eastern Parts of Abyssinia. By Dr. J. D. Clark. (Occasional Publications of the Cambridge University Museum of Archæology and Ethnology—Vol. 2.) Pp. xx+386+52 plates. (Cambridge: At the University Press, 1954.) 105*s.* net.

DR. DESMOND CLARK, curator of the Museum at Livingstone, North Rhodesia, is already well known for his fine work on the banks of the Zambezi near the Victoria Falls and other sites in Northern Rhodesia. He was good enough to welcome me there in 1948.

In a series of short articles he has already revealed to us some discoveries he had made during his military service in Somaliland and Ethiopia during the Second World War. His sojourn there was prolonged during another two and a half years (1941–46) and he has returned there since to complete certain researches.

The author has used this work as a thesis for a doctorate at Cambridge. He has studied more thoroughly than any other prehistorian this eastern horn of Africa, extending 2,500 miles both in length and breadth.

After the usual and most useful physical, geographical and climatic descriptions of this immense region which shared in the violent tectonic phenomena forming the 'rifts' which upset the whole surface of East Africa, the author gives an account of the explorers preceding him: Bourg de Bozas (1901); the Italians, Stefani, Paoli and Puccioni (1913–36); Cipriani (1927–32); Graziosi and Puccioni, and others; not forgetting the earlier ones, Seton Karr, Paulitschke and Winkenberg (1880–97). Dr. Clark was also familiar with the work of Teilhard de Chardin, Paul Wernert and myself in 1933, both in the region around Obock (French Somaliland) and near Diré Dawa.

Near Obock, Father Teilhard and I made the only study attempted so far of the 60- and 30-metre raised beaches of Somaliland. The author describes this in detail, but appears to me to exaggerate when he says the oldest industry is as late as what he calls Acheuleo–Levalloisian. Personally, I think it far older, and likewise in the neighbourhood of Diré Dawa. He does not mention a bi-faced tool which I think probably Abbevillian, which I picked up at Warka (Harrar); it is true that it was not in its original position, but I think it would be well worth while to search for its original site.

Speaking of the extraordinary and abundant industry consisting of picks, found by Paul Wernert at the end of the Gulf of Tadjoura and near Lake Assal, which has not been found in any other place, the author does no more than mention it.

Three very crowded chapters of 109 pages follow, on the Quaternary geology and stratigraphy of British Somaliland, the Danakil Rift and the north and east coasts. Dr. Clark devotes some pages to the problems of the successive sea-levels in the straits and discusses the possibility of an Arabo–Somali continental land-bridge. These pages contain a wealth of most valuable observations and information, a résumé of which is impossible; but their content is indispensable for any future explorer of these regions.

After a very short chapter on prehistoric terminology, the author passes in review the different groups of industries represented, according to him, in the regions mentioned; first, Acheuleo–Levalloisian; then Levalloisian; the Stillbay cultures of Somaliland and the industries derived from the Magosian, Magosio-Doian, Hargeisan; then the Somaliland Wilton culture with the Neolithic and Strandlooper influence. Every industry *in situ* (and there are a great many sites, some not very important) has its stratigraphy described, enabling the author to correlate them with the sequence of regional climatic conditions, and he gives a precise analysis of the types of chipping and weapons produced, which is quite satisfactory, though no doubt some of the attributions might be disputed. It seems to me most improbable that nothing can be classified as older than Acheuleo–Levalloisian.

A wealth of sufficiently good illustrations, banished to the end of the volume, enables one to identify the types described and may also suggest that this Old Palæolithic is rather too simplified. It is curious to note how it is concentrated around Obock and the region of British Somaliland. Then comes the true Levallois, a long and monotonous stage, rightly related to the North African and Palestinian Levalloiso–Mousterian.

The Stillbay culture (Moustero–Solutrean) follows and is derived from the Levalloisian, as in all southern and tropical Africa. Its chief characteristic is flaking, in which pointed triangular flakes predominate, or blades, the latter sometimes blunt-backed burins. Stillbay is derived chromatically from Magosian, in which microlithic forms appear, giving place to several variations; one, the Doian, is markedly microlithic and had already been noted to Graziozi, who called it Eibian. As for the Hargeisan facies distinguished by an abundance of blades and burins, always few in number in the other facies, the author attributes this to an influence coming from the north, which seems plausible. The Doian industry is massed, rather curiously from a geographical point of view, between the two rivers Tana and Yuba. Besides microliths, bi-faced arrow-heads with a concave base are found in it, and other types familiar in the Somaliland Wilton facies.

Very few pages are devoted to the painted and engraved rocks (there are not many), which, near Harrar, I had studied, in the Porcupine Cave at Diré Dawa and at Genda Biftou (Sourré). The author adds some information on Lago Oda, where Wilton is found. I am not as certain as he is that the schematic designs in the Porcupine Cave are not earlier than the semi-naturalistic ones at the other two sites. It is, however, true that another stylized series seems to follow them, as the author remarks; but there is one point which must be noted, when attempting to judge the age of all these paintings: it is, that superposed on oxen with great horns of the type of those in Genda Biftou, at Lago Oda and other sites, there are splendid fat-tailed sheep. The date of their introduction into the country could, I think, easily be obtained, though this can wait so that there could be more evidence and certainty.

My suggestion that it would be well to compare the animals painted with those of ancient Egypt, as well as the way the cows' udders were represented, of which I had made a study, led me, though with a certain reserve, to consider they were related. The author seems rather favourable to this idea, though he appears to be astray in his date (the dawn of the Christian era), which seems to me excessively short.

In the last pages of the book, Dr. Clark attempts to establish a correlation between the industries and climatic phases and to compare the results obtained with those in other regions in Africa and southern Arabia. In short, this book is conscientious, instructive and will be extremely useful to future explorers of the country.

H. Breuil

CONNECTIVE TISSUE

Connective Tissue in Health and Disease

Edited by Dr. G. Asboe-Hansen. Pp. 321+1 plate. (Copenhagen: Ejnar Munksgaard, 1954.) 50 kronor; 7.50 dollars.

"AND, finally, owing to the difficulty of investigation, and a certain amount of weariness produced by unprofitable discussions, the connective tissues have recently been somewhat neglected by microscopists." Written by Heinrich Frey during the latter half of the past century, these words could have applied equally well to most of the years which have passed between then and now. Although it was

known during the seventeenth century that parts of the body were fibrous in nature, the name 'connective tissue' was actually proposed by Johan Muller in 1830, and later Kolliker suggested as an alternative term, 'sustentacular tissue'. Reichert organized the existing knowledge on this tissue in 1845, and Virchow demonstrated its importance in pathology in his famous work published in 1858. That the sole function of connective tissue in the normal animal was to act as scaffolding was the accepted view at the time of publication of Frey's work. The English translation (1874), in fact, says "Connective substance takes but little part in physiological occurrences of the mature and healthy body".

This view continued to be generally accepted until relatively recent times. However, since the time of Virchow and the recognition of a variety of cells in connective tissue, it became obvious that it played an important part in inflammatory processes, and microscopical studies of wound healing demonstrated its essential role in the formation of scar tissue; but the problem remained—what part does it play in the normal functioning of the body?

Its mechanical function is obvious; the supporting nature of the deep fascia in the preservation of form and contour and the facilitation of muscular attachment and movement are known to every student of anatomy. Modern techniques have added substantially to our knowledge of connective tissue. The complex cross-striation of collagen fibres is well known and so too are the presence of hyaluronic acid and chondroitin sulphuric acid in the ground substance. The water-binding ability of the ground substance and its role in œdema are also recognized.

The ground substance is the link between the blood vessels carrying oxygen and nutriment and the organs and tissues which require them. Its molecular organization appears to be adapted to facilitate the rapid diffusion of such substances. The adventitia of many blood vessels is, in fact, impregnated with phosphatases, suggesting that it may be acting as a broad membrane with selective control of the substances which pass through it—a suggestion which is supported by the presence of phosphatases in the endothelial cells of the capillaries. In 1924, Höjer demonstrated the dependence of the connective tissues upon adequate supplies of vitamin C; this in the following twenty-five years resulted in a series of papers emphasizing the importance of this vitamin in fibre production and the development of scar tissue in wound healing.

More recently, in 1949, Hench and his colleagues showed that the pituitary, acting through the adrenal, by the medium of adrenocorticotrophic hormone exercised control over connective tissue. Cortisone, in fact, was found to depress fibre production in inflammatory conditions. This work has stimulated further interest in a tissue which was already gathering in importance, and as the full battery of modern techniques becomes turned upon it, may be expected to yield still more of its secrets and to demonstrate still further its fundamental functions in health and disease.

In Asboe Hansen's "Connective Tissue" we have a series of chapters by experts which deal with a wide variety of aspects of the subject. They are, as the editor says, pioneers of modern connective tissue research and their contributions are worth reading from this point of view alone. The subjects covered range from morphology and chemistry of the collagen fibres and the ground substance, through the effects of hormones, disease and ageing upon connective tissue in general, to a consideration of its relation to collagen diseases, arthritis, arteriosclerosis, ophthalmology, and cancer. There are many gaps; for example, there is no proper consideration of the elastic fibres although they are referred to in a more or less desultory fashion in some of the chapters. The effects of cortisone and of vitamin C deficiency also receive a cursory treatment. There is no doubt that everyone who has an interest in connective tissue must read this book; but it must be appreciated that it is not a comprehensive work, and the individual chapters do not deal exhaustively with the subjects they discuss. The book is, in fact, fundamentally a collection of essays on selected topics related to connective tissue. Its value, however, is greatly reduced by the unforgivable lack of an index.

G. H. Bourne

GEOLOGICAL HISTORY OF CALIFORNIA

Earth Song

A Prologue to History. By Charles L. Camp. Pp. xi+127. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1952.) 37*s*. 6*d*. net.

THE title of this book gives at the first glance little indication of its merit or, indeed, of its scope, and only those who know the author or his other works will realize the import of the song. This is, in fact, a geological history of the State of California with a general account of the life and the reconstructed appearance of some of its former inhabitants during some five hundred million years.

It may therefore be thought that it is just another American palæontological book. In some ways it is, with all the wealth of illustration and of interest that such books present. But California has a separate history, and at least one of its geological deposits, that of Rancho la Brea with its asphalt trap, is unique. Dr. Camp gives an account of the Californian rocks and deals, period by period, with the life of the early sea, the conquest of the land, and the rise of amphibians and reptiles, leading to the ampler record of the mammals. The whole is embellished by a fine series of pencil drawings by William Gordon Huff, and these are worthy of inspection for their intrinsic interest as well as for the fact that new and authoritative reconstructions of vertebrate fossils always have a great appeal. The book also deals with the rise of man in a general way, since there is a regrettable deficiency of fossil men in this Golden State, but goes on to the description of the early Red men and the Folsom implements. There are excellent maps and charts from the pen of Owen J. Poe and a number of the charts deal with the chronology. Some of these are of considerable value, since the correlation of the delightful-sounding Californian formational and later chronological names with European counterparts or quasi-equivalents is difficult. The book contains a glossary, a very useful list of references, and an index. There are introductory passages to the chapters in a rather poetic American style; but on the whole the text is excellent and informative and the book should certainly find a place in major reference and university libraries.

W. E. Swinton

INSTABILITY OF THE EARTH'S AXIS OF ROTATION

By T. GOLD

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THE axis of rotation of the earth undergoes certain changes of direction, some of which are the results of known causes, whereas others are not yet understood. The major movement is the precession, whereby the axis of the geoidal figure of the earth together with the vector of the angular velocity and that of the angular momentum sweep out a cone of 23° once in twenty-six thousand years. One effect of this is that the year as defined by the seasons is different by one part in twenty-six thousand from the year as defined by the earth's position on its orbit. The precession is due to the motion of the spinning earth under the action of an external couple, namely the gravitational couple exerted by the sun and the moon upon the non-spherical earth. That couple depends on the relative position of these objects and is therefore not steady in time. The result is a superimposed wobble in the direction of the axis of rotation, and it has been given the name of 'nutation'.

There exist, however, other effects not produced by external couples but by a redistribution of matter or angular momentum on or within the earth. They are movements whereby the direction of the axis of rotation remains nearly fixed in space, while the earth itself moves relative to it. The absolute angle by which the axis of rotation moves is some three or four hundred times smaller than the movement of the earth, and it is therefore only the latter which is a measurable effect, usually noted as a variation in the apparent latitude of observation points on the surface of the earth. The angle involved is small, of the order of $\frac{1}{4}''$; the motion is complicated and irregular, but two components can be recognized, one of a period of one year and one of a period of fourteen months.

These movements of the earth relative to its axis are of great significance to theoretical work on geophysics. While the other motions are accurately described by the rigid-body dynamics of the system, this one has its origin, period and damping related to physical conditions on or in the earth. The annual term is thought to have its origin in atmospheric effects[1,2]. The origin of the excitation of the fourteen monthly motion is unknown; but it is understood that the period is the one corresponding to the 'free' or 'Eulerian' nutation. That period is given for a rigid body by $\left(\frac{A}{C-A}\right)T$, where A, A, C are the principal moments of inertia and T is the rotation period. This value would be 305 days for the earth, but a very modest amount of elastic deformation would lengthen it to the observed 420 days. The mean Young's modulus of the earth has to be of the same order as that of steel for the period to suffer as little lengthening due to the deformation[1].

The question of the excitation and the damping of the motion is more difficult to treat. There is no clear-cut way of distinguishing the component of the motion which corresponds to the unknown excitation from that which corresponds to the decay due to internal damping. It can, however, be inferred, on the assumption that the excitation possesses no consistency, that the damping time must be fairly short and cannot be more than a few periods, ten at the most, for a decay to $1/e$ of the original amplitude in the absence of further excitation. Alone the actual amplitude of the motion, together with an estimate of the excitation taken from just those occasions when the amplitude suffered an increase, puts a limit of this order on the damping time; with lesser damping the amplitude would be expected to be greater according to the statistical addition of exciting impulses. (Jeffreys quotes an estimate of fifteen years; Walker and Young, recently, one of three years[3].)

Where does this high damping arise? The requirement is for some relative motion to occur in which energy can be dissipated. But the obvious places on the surface, such as the atmosphere and the oceans, cannot be responsible, for the material that moves relative to the solid part of the earth requires to have more than a certain moment of inertia in order to be able to cause the damping at all; and it then requires to be coupled in a suitably dissipative way to the solid part of the earth. The moment of inertia of the atmosphere and oceans is insufficient. The liquid core of the earth has been discussed as a possible source of the damping, but its small moment of inertia (10 or 12 per cent of the whole) can be shown to rule it out, too[4].

The large damping must then arise from a dissipative deformation of the solid part of the earth. The existence of a high Young's modulus is no guide to the plastic flow that may occur in the material, or to the relation between the flow and the stress. It is difficult to see in what other way this lack of permanent stiffness could be measured. The damping of earthquakes is scarcely relevant, as it is concerned with periods 10^8 times shorter. The solid-body tides of the earth are concerned with a period a thousand times shorter than the nutation, and even there the presence of a small amount of dissipation would escape detection.

The existence of gravity anomalies over large regions is sometimes taken as an indication of long-term stiffness down to a depth of at least a few hundred kilometres. Such gravity anomalies are related to long-lived tectonic features and are therefore quite reasonably inferred to be long-lived themselves. But on the other hand, the bulk of the materials on the surface of the earth—the continents, the mountains—are not supported by substantial non-hydrostatic forces from depths below a hundred kilometres. If the occurrence of permanent stiffness down to great depths much below a hundred kilometres were a world-wide phenomenon, then it would be a matter for surprise to find that all the major deformations of the crust that have occurred have managed only so rarely to pile material up on an underlying stiff base to produce a very large gravity anomaly. The information obtained from gravity surveys therefore suggests that, except for a few areas, there is no appreciable permanent stiffness

below about a hundred kilometres. Stiffness in some localities is, of course, not decisive for the behaviour of the wobbling earth.

Another line of argument also suggests the absence of permanent stiffness of the main geoidal shape of the earth. At present the solid part of the earth is very nearly the equilibrium shape appropriate to the present speed of rotation. Any severe departure either way from this shape would show itself very simply: the oceans which take up the equilibrium shape instantly would then dominate either at the poles or in equatorial regions. In fact, the distribution of land and water shows no significant tendency of such a type. On the other hand, the earth's speed of rotation is believed to have changed significantly in geological time. It has been changed either by giving up angular momentum to the moon through the agency of tidal friction—and the moon shows signs of a tidal bulge appropriate to a greater proximity to the earth—or the speed of rotation may be determined by the resonance with atmospheric tides, in which case it must have changed substantially with changes in the structure of the atmosphere[5].

There exist many forms of non-elastic behaviour of solids other than plastic flow, and all of them lead to dissipation of energy in a stress cycle. "Elastic after working", for example, has been mentioned by Jeffreys in this context[1]. Plastic flow is, however, the simplest type of behaviour, and it occurs in most solids in the vicinity of the melting point. It is a behaviour in which there is no 'memory' in the material, the instantaneous stress defining the instantaneous elastic strain and the instantaneous rate of flow. There seems to be no case for invoking any of the more complicated types of behaviour in which the material possesses a 'memory' determining its reaction to a stress, such as is often the case with materials composed of large and complicated molecules. Also plastic flow must in any event be invoked to account for the absence of long-term rigidity which has been inferred from other considerations.

The speed of plastic flow can now be deduced on the basis of the assumption that the damping of the free nutation arises entirely from this cause, and that the characteristic time is ten periods. If there were an angular separation between the axis of figure and the axis of rotation, then the plastic flow would be such as to allow the figure to become deformed and hence its axis of symmetry to move. In the absence of other effects, the axis of symmetry would then approach the axis of rotation by ten per cent of their angular separation in each period of fourteen months. For the motion of nutation itself this plasticity would result in dissipation only; but other motions with slow secular effects are made possible.

The long-term stability of the axis must then be considered. A spinning sphere would possess no stability of its axis of rotation at all; the smallest beetle walking over it would be able to change the axis of rotation relative to markings on the sphere by an arbitrarily large angle; the axis of rotation in space would change by a small angle only. What stability the earth's axis possesses against movement relative to the solid earth is derived from the geoidal shape, implying that it is spinning around the principal axis of inertia of greatest moment and hence possessing less kinetic energy than if it spun with the same angular momentum around any other axis. This complete stability against a secular change is therefore dependent upon the stability of the shape. If, as a result of a slight redistribution of mass, the instantaneous axis of rotation were to be moved by a small angle (such as is the case in the free nutation) then, if there is plastic flow, the axis of figure would slowly follow. For example, let us consider a redistribution of mass the dynamical effects of which are the same as those of an excess mass situated somewhere neither at the equator nor at the pole. The damping will assure that the initial wobble is stabilized to a spin around the new principal axis. But so long as there exists the excess mass at one place, the axis of the geoidal shape cannot be also a principal axis. Therefore, as the geoidal shape alters so as to become adjusted to the new axis of rotation, so the axis of rotation moves on. The magnitude and the angle of latitude of the excess mass define, in fact, not simply an angle of displacement of the earth's axis relative to the solid surface: they define an angle between the instantaneous axis of rotation and the axis of the geoid. The magnitude of this angle in turn defines the stress and hence the rate of flow altering the shape, given by the constants of plasticity of the earth. The resulting rate of flow gives the rate at which the axis of the geoid moves relative to markings on the earth, and that is now also the rate at which the rotational axis moves relative to the earth, though, of course, remaining nearly fixed in space. It is as with the ass and the carrot hanging from a stick held by the rider; to be more precise, as if the ass would run faster the farther the carrot was held in front of his nose. But how far can the ass be made to run by this method?

In the movement of the earth the latitude and the excess mass were decisive. The angle between the two axes and therefore the rate of polar wander will be greatest for an excess mass at a latitude of 45°; and there will be no position reached in the motion where the angle vanishes until the axes have swung around so as to make the new equator go through the position of the excess mass. The angle α between the axis of figure and the axis of rotation is proportional to $M \sin\theta \cos\theta$, where M is the excess mass and θ its latitude. The rate of deformation and hence of polar wander must increase with increasing α, but the actual relation between the quantities depends upon the details of the non-elastic properties of the material. The rate of plastic flow as well as other departures from elasticity generally increase with increasing stress faster than in proportion to the stress. If, therefore, the long-term effects were connected with the occurrence from time to time of larger angles α than can be seen in the free nutation at present, one would merely be under-estimating the amount of plastic flow if one assumed the rate to be proportional to α and given by the damping of the free nutation. The distance to which the wander will proceed is independent of M: it is simply the angle θ. One has here the situation of a secular instability where a small disturbance does not produce a small effect but where it produces a large effect slowly.

Sir George Darwin considered a motion of that sort[6] and described it qualitatively; but in summing up he considered it unlikely that the motion had, in fact, been taking place, for he would have expected it to have resulted in a change of the distribution of land and water. Geologists, however, had assured him of the permanence of the oceans. Due to the new knowledge of isostasy, this argument has by now lost all force. In the case of perfect isostasy, an ocean basin would be characterized by the occurrence of a region of greater average density

below the ocean floor. The depth of any point of the basin below a certain equipotential surface such as the sea-level would be given solely by the local distribution of density, and would therefore be unaffected by a change of the geoidal shape to a new axis. The actual isostatic compensation is not perfect; but still it is known that there is a considerable degree of correspondence between the heights of the surface and the densities below it. In so far as that is true, the distribution of oceans and continents would remain unaffected by polar wander. The details of the nutation were also not available to Darwin, and the case for plastic flow was therefore weaker and lacking a quantitative estimate.

The dynamics of the problem do not introduce any long time constants, and the speed of polar wander must be entirely dictated by the rate of plastic flow. With the plasticity derived from the damping of the free nutation, we can make an estimate of the speeds involved; for the rate of movement of the axis of figure would have to be one-tenth of the angle α, or more, per annum. If a continent of the size of South America were suddenly raised by 30 metres, an angle of separation of the two axes of the order of one-hundredth of a degree would result. The plastic flow would then amount to a movement of one-thousandth of a degree per annum. The earth would hence topple over at a rate of one degree per thousand years or by a large angle in about 10^5 years. The order of magnitude of the speed of this process would therefore be preserved if the raising of a continent by 30 metres occurred not suddenly but in a time of the order of 10^5 years. This rate is perhaps higher than could be expected. A continent of that size does not rise perhaps at such a rate; and the observed degree of isostasy on the earth suggests that the rise of a mass is associated with such a redistribution of material that the actual increase of moment (in the sense of the excess mass discussed before) is very much less than corresponds to the elevation of the surface. As in this discussion the rate of tipping is proportional to the square root of the rate of elevation of mass, the estimate will not be as rough as the geological data must necessarily be. A rate of elevation of the continent by three metres in 10^6 years is certainly a low figure and would result in a time of 10^6 years for a large-angle change in the orientation of the earth relative to its axis of rotation.

This, then, is the possible effect using the plasticity suggested by the nutation. But what motion must we then expect in geological times, when there are constantly variations in the distribution of masses? It is perhaps easiest to consider this with the aid of a model of the earth which, though it may be false in other respects, possesses just the bare features required for these dynamical processes. That model would consist of a plastic spheroid representing all the earth below a hundred kilometres depth, of such plasticity that no forces of hydrostatic disequilibrium can be upheld there. On it there is floating a crust consisting of a close mosaic of pieces of different densities. This model would possess different values of the moments of inertia about different axes of rotation. Though in each case the interior will become the appropriate spheroid, the non-uniform crust will be in a different relation to it; and the blocks of the crust made of lighter materials will make a greater contribution to the moment of inertia at each latitude than the heavier ones, as they represent the same quantity of material, but at a greater distance from the axis. The secular instability that we have discussed is such as to rotate this body relative to the axis of rotation until its spin is around the axis of the greatest possible moment of inertia. Movements of material on the surface of the earth correspond to changes in the masses and mean densities of the blocks. It will therefore occur from time to time that a new distribution arises that would produce a greater moment of inertia for the body if it spun around another axis. Whether this situation must now be expected to produce a secular motion whereby the axis is continuously hunting the direction of the greatest possible moment of inertia is not immediately clear, for the movement of the axis in turn causes certain redistributions of masses of air and water, and those may be in such a sense as to help or to hinder the movement. Possibly the most important effect of that sort is circumpolar glaciation producing large and rapid variations of mass at latitudes not so far from 45°, where the dynamical effect would be a maximum, and altering the sea-level everywhere, also in intermediate latitudes. In considering the small present-day movements of the axis, Munk and Revelle[7] came to a similar conclusion and stated that the pole should be expected to move towards the location at which most ice is melting at present.

It may be, then, that instead of a passive stability of the pole due to stiffness of the shape of the earth, there is merely from time to time a stability arising from a feed-back process that balances out slight asymmetries that arise. If indeed glaciation is the dominant effect then, for example, the pole situated in a circular ocean extending over some 20° of latitude would tend to be in a stable position. Any departure of the pole from the centre of that ocean would cause glaciation on the land towards which it had moved (the ice floating on the water has no significant dynamical consequence), and such an addition of mass in that locality would act in the sense of pushing the pole away from that land. From the work of Jeffreys[1], Mintz and Munk[2] and others, it is clear that atmospheric effects may also contribute to such mechanisms.

The movements of the pole relative to the surface of the earth that have been measured in the past fifty years do not amount to much. If an estimate is made of the centre of the curves of travel of the North pole during the nutations, then it appears that this centre may have been drifting by something of the order of 0·1″ in the direction of Newfoundland in the past fifty years (corresponding reasonably well to the continued melting of Greenland ice)[7–9]. Such a rate of movement, even if it continued in the same direction, would thus take about 2×10^8 years to turn the earth over by 90°. There is also other evidence in past geological epochs for long intervals, of the order of fifty million years, of no drastic climatic change. On the other hand, there is ample evidence that drastic changes of climate have occurred occasionally in geological time, and such changes have served geologists for the division of time into geological epochs. It is thus tempting to suggest that there have been just a few occasions when the axis has been 'free' and has swung around as rapidly as would be given by the stiffness of the earth and the rates of tectonic movement, leading to a time-scale of the order of 10^5 or 10^6 years, but scarcely longer. But then in its rapid movement it has encountered a trap where it was caught within a small angle by the shifts in masses which its movement itself induced. It must then have remained

in that neighbourhood until either there was a sufficient tectonic change to lead to an unbalance greater than could be compensated by glaciation or atmospheric effects, or until the distribution of land and water had been so modified as to destroy the mechanism of the trap. There would then have followed another period of hunting until a new trap became operative. The recent observations of fossil magnetism of rocks and sediments show such great promise that we can expect before long to have a good indication of the movements of the pole that have, in fact, occurred in geological history. It is known already that a movement of at least some regions relative to the position of the pole is indicated by the results, and this constitutes a further item of observation along with such geological items as the glaciation of now tropical zones, that force geophysicists to consider that either continental drift or polar movement must have occurred on a substantial scale. In due course the magnetic data will make the distinction between the two. The occurrence of continental drift over great distances would imply new and surprising data about the construction of the earth and in particular its crust; while the occurrence of wandering of the poles over great distances would fit in well with all that is known about the earth, and would reaffirm what can already be inferred from other data.

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SCIENTIFIC INTELLIGENCE AND DEFENCE

By CHAPMAN PINCHER

SCIENTISTS in Britain are to play a much bigger part in Intelligence work as a result of recent changes effected by the Defence Ministry. *Ad hoc* panels of scientists and technologists expert on particular matters are to be set up to help in the interpretation and collation of certain kinds of information collected through Intelligence sources.

These scientists will be drawn from the universities and from industry as well as from Government establishments. After security clearance they will be asked to assist in the analysis of information about foreign weapons, equipments and defence potentialities.

Since the War, responsibility for this type of work has rested nominally with the rather small Directorate of Scientific Intelligence in the Defence Ministry. That arrangement has proved to be impracticable. The Fighting Services have become so technical that it is no longer possible to draw a line between the routine Intelligence work for which they should be held responsible and scientific Intelligence. In fact, Intelligence chiefs have despaired of defining scientific Intelligence except in the general terms that it is the knowledge and appraisal by scientific methods of foreign developments in science and technology.

The Directorate of Scientific Intelligence has therefore ceased to exist as a separate unit. It has been absorbed into the Joint Intelligence Bureau, which, though still retaining its name, has been given much wider functions.

The Joint Intelligence Bureau will henceforth serve as a central Intelligence agency to which a wide range of strategic Intelligence information will be transmitted. Its staff will be responsible for ensuring that the utmost possible use is made of such information.

This change brings the British system more closely into line with the Intelligence methods adopted by the United States Government after the War. The failure to appreciate the imminence of the Japanese attack on the American Fleet at Pearl Harbour was later attributed to defects in the higher levels of the Intelligence system. Information clearly pointing to the attack and its approximate date was available in the various separate Intelligence agencies; but because there was no central authority it had never been properly 'appreciated' and had not been put forward at the levels where decisions are made. The U.S. Central Intelligence Agency, now headed by Mr. Allen Dulles, brother of Secretary of State John Foster Dulles, was therefore set up to ensure proper utilization of Intelligence information in the future. Its necessity has been enhanced by the growing danger of the possibly decisive influence in future wars of 'Atomic Pearl Harbours'. All Intelligence information from the Fighting Services, the Secret Service and the Atomic Energy Commission is now canalized to the U.S. Central Intelligence Agency.

The British reorganization has left the Fighting Services responsible for their own operational Intelligence work—an arrangement which is thought to be more flexible as it leaves the Services less isolated from the central agency. It is believed that the people who interpret scientific Intelligence will be more effective if they retain closer connexion with the Service in which they themselves are most expert.

Major-General Sir Kenneth Strong, former chief of the Joint Intelligence Bureau, remains head of the enlarged organization. Mr. H. S. Young, who has been acting director of scientific Intelligence since the resignation of Prof. R. V. Jones from that post last year, has been appointed a deputy director of the Joint Intelligence Bureau.

After collation by the Bureau, matters of importance will be put forward to the Joint Intelligence Committee, a high-level group which includes the heads of all the Intelligence agencies and a Foreign Office representative. This committee will produce a 'considered view' on the matters in hand and make it available to Service commanders, ministers, senior Civil servants, ambassadors and others who need it.

The enlarged Joint Intelligence Bureau is responsible to the Defence Minister, Mr. Harold Macmillan, who has a direct voice in the Cabinet. As an additional link with the Joint Intelligence Committee and the Intelligence chiefs, a post of Scientific Adviser on Intelligence to the Defence Minister has been created as part of the new arrangements. Mr. E. C. Williams, formerly director of operational research in the Admiralty, has been appointed to it.

Though these changes have been made entirely on the basis of British experience, it is believed they will cause satisfaction in Washington—an important consideration, as fears about British security have held up interchange of information on atomic weapons and other defence developments.

OBITUARIES

Sir Edward Mellanby, G.B.E., K.C.B., F.R.S.

Statesman for a quarter of a century, scientist for half a century: one feels in preparing this notice as Mellanby himself said he felt when faced with the preparation of the Hopkins Memorial Lecture, that the task requires a "degree of knowledge, skill, judgement and sympathy . . . almost unattainable"[1].

Sir Edward left the stamp of his skill as a statesman on the work of the Medical Research Council, of which he was secretary for sixteen years. The present members of the Medical Research Council have in the following words recorded "their high appreciation of his great services to medical science. As Secretary of the Council from 1933 to 1949, after being a Member since 1931, Sir Edward Mellanby took the leading part in the difficult tasks of deploying the Council's scientific resources in support of the national effort during the second world war and of reconstructing and notably expanding the organisation thereafter. To these responsibilities he brought an intense regard for scientific truth, a wide knowledge and deep understanding of medical problems, a sure sense of what was important in research, and a constant desire to encourage all who showed ability as investigators and ideas likely to lead to real discovery. His endeavours had great success"[2].

It has been said that he was in some ways "not well cast as an administrator"[3]; but he brought to this highly responsible post the qualities of a statesman—sagacity, far-sightedness and skill in the management of practical affairs—in unusual measure; he deputed to the professional administrator those matters which could safely be entrusted to him. It was characteristic that on one occasion he denied that the Council had a policy in financing research workers except "to find the right men and back them in every way possible"[4]. He often said that the recruitment of first-class administrators was an easy matter compared with securing men of the best type for medical research; such men are, he said, "limited in number, and cannot be appreciably increased by any known method. They must in general be what is known as clever men, but cleverness alone accounts for little. In addition, they must be men of strong character, capable of hard and often disheartening work, with power to distinguish truth from falsehood, prepared to spend their lives with limited social contacts and to forego riches". Such men, he recognized, are rare, and he considered that one aspect of the Council's work was, short of this ideal, "to attract able men, and by providing financial assistance and ensuring the proper kind of training, helping them to a career of medical research"[5]. While he stoutly maintained that the supply of the right type of man was the basis of success in medical research, he defined the main function of the Medical Research Council as the promotion of "scientific investigations for the acquisition of knowledge likely to be of value for the prevention, diagnosis, and treatment of disease, and for the maintenance of normal health and full human efficiency"[6].

On the many occasions when he gave important named lectures he drove home with telling examples the benefits to mankind in the past hundred years of the application of the discoveries in medical science. It is fifteen years ago since he opened his Rede Lecture with the words: "Probably at no time in the world's history has the average citizen of this and most other civilized communities felt so insecure against death by violence. At no time in the world's history has the same citizen had reason to feel so secure against death by disease". Concluding this Lecture, he claimed that "medical science and its instrument, medical research, have indeed justified themselves. For every problem—social and economic . . . the only solution is more knowledge and more wisdom to use this knowledge. There is no limit to the amount of knowledge to be gained, if the medical scientist is given the opportunities and facilities for his work. Would that the same could be said about the wisdom necessary to make the best use of this knowledge!"[7].

One principle that he returned to time and again was the difference in effectiveness in research of the experimental method over observation: "Where", he said, quoting Lord Moulton, "we are reduced to observation, science crawls. Where and in proportion as you can use experiment, science advances rapidly"[8]. He recognized, however, "the enormous difficulties of the experimental method in biological investigation due to the complexity of the inter-acting materials"[9]. "Long experience has taught me", he said in his Harveian Oration, "that it is seldom in the facts of discovery, but rather in the interpretation, especially the first interpretation, that mistakes are made"[4].

In his personal work, Mellanby considered himself fortunate to have come as a medical student in 1902 in the scientific care of Hopkins, in whose laboratory he later spent two years (1905–7) as a research worker. Mellanby published his first paper in the *Journal of Physiology* in 1908 on creatine and creatinine. Even at this time he had begun to pry into the effects of disease, in this case liver damage, carcinoma and other conditions likely to affect creatine metabolism, and his broad biological interest was also already manifest in that he examined the creatine content of various animals and its occurrence in the course of development of several of these in an attempt to discover whether from ontogeny and phylogeny light might be cast on the evolution of vertebrate animals. An incidental observation in the course of this work—that creatine is destroyed by bacterial action—led him in later papers to examine the problem of the effects of the bacteria from the alimentary canal on various substances. One outcome of this work was the discovery that an organism in the alimentary canal could convert histidine into histamine, a substance now of great biological importance. He continued the study of creatine with reference to the metabolism of lactating women, which was the subject of his first communication—presented by Hopkins—to the Royal Society early in 1913. Next he published the results of an attempt to discover the relationship between the formation and absorption of histamine and diarrhœa and vomiting in infants[9]. Thus there was already evidence of his interest in the interaction between clinical and experimental work in the laboratory, the theme of a book published in 1934, "Nutrition and Disease", based on the Croonian Lectures delivered to the Royal College of Physicians in 1933. By 1918 he had begun to publish the results of his investigations on the production of experimental rickets. This investigation arose out of a plan drawn up by the original Medical Research Committee in 1913. Rickets was included in a list of major disabling diseases besetting Great Britain at that time. Mellanby was asked to investigate the part processes of oxidation might play in the etiology of the disease.

His experiments soon demonstrated that serious bone abnormalities result from faulty diet, and this oriented the work towards the hypothesis that the diet might well be a primary factor in the etiology of the disease. From that time onwards investigations became more and more along dietetic and nutritional lines, as seen in "A Story of Nutritional Research", his Abraham Flexner Lectures published in 1950[10]. One result of this work is that whereas at one time "stunted children with bandy legs were so common as either to pass unnoticed or be a source of amusement", nowadays if we saw them "we would be angry, because we would realise they were the products of ignorance or negligence"[8].

It was his involvement in this investigation of rickets that decided Mellanby not to return to Cambridge when invited to by Hopkins when the latter became, in 1920, the first professor of biochemistry at Cambridge. It was, he has said, a crucial decision and probably a wrong one, and hereafter he felt he could no longer be regarded as a biochemist. By this time the index to his publications had been once through the alphabet; before his death the alphabet was to be exhausted more than twice again.

There is space here to deal with only a few of the main themes of Mellanby's research since that time. One was the presence in food of substances having specific harmful effects, an inquiry which arose out of the work on effects of cereals on bones. Evidence was obtained of the presence in some foods of an anti-calcifying substance, later identified as phytic acid[10]. There was, he demonstrated, antagonism between phytate and vitamin D, the former trying to expel calcium from the body, the latter promoting its absorption and retention. This anti-calcifying factor he included in a group of substances which he called toxamins, now more widely known as anti-metabolites.

Running almost in parallel with the work on the hardening of bones was his study of the shaping and modelling of bones—work which began with an observation made in the study of rickets that in vitamin A-deficient animals damage to the nerves of the animal occurred, with the development of severe ataxia and loss of sensation of various kinds resulting in deafness, blindness and anosmia. Mellanby was ultimately able to show that, in his own words, "these two inseparables, vitamins A and D, the David and Jonathan of nutrition, whose faithful alliance in distribution and similarity of many chemical and physical properties has caused so much trouble to hosts of physiologists, biochemists and other scientists, work in harmony and on the same structures at the time of their active careers in the animal body. Although their functions are different, they unite in directing and controlling the building up and maintenance of bone structure"[10]. Despite the growth of knowledge of the effect of vitamin A on the body to which he had largely contributed, Mellanby continued to be dissatisfied because so little was known about the site and the mechanism of its action. He determined to examine the direct effect of the vitamin on the tissue by tissue-culture techniques, and after preliminary exploration of the problem he sought the collaboration of Dr. Honor Fell. They found among a number of other interesting results one exciting effect on tissues of plasma with a high vitamin A content, namely, that chick ectoderm develops not into normal skin, but into more highly developed mucus-secreting ciliated respiratory epithelium. Returned to normal plasma, such tissue reverts to normal skin. Likewise in culture in high vitamin A plasma, corneal epithelium becomes hyperplastic, like the conjunctiva. Clearly, since metaplasia is most prominently seen in cancer, this discovery has a bearing on this outstanding unsolved medical problem. He also thought that a similar type of approach may well be rewarded in the study of other unsolved problems of disease involving degenerative and other structural changes due to altered metabolism.

Another recent discovery, and again an extension of earlier research, is the experimental proof that agenized flour is toxic to dogs and other animals. The substance formed by the action of agene (nitrogen trichloride) on a wheat protein has been identified as methionine sulphoximine. The mechanism of the biological action of this substance is still unknown. This discovery has had far-reaching effects in emphasizing the need for attention to be given to the effects of the chemical manipulation of food. Recently steps have been taken to secure international action in this field. Commenting in his Sanderson-Wells Lecture on the increased incidence in the past fifty years of certain morbid conditions, Mellanby said that he found it "difficult to avoid the conclusion that some at least of these increases in disease are due to errors in living recently introduced or greatly expanded in modern times", and that the effects of chemical manipulation of foods provide "at least a subject worthy of enquiry" and one which "might well be considered whenever a disease commonly found in countries which use these methods has resisted all efforts of the investigator to find a satisfactory ætiological basis"[11].

These examples by no means exhaust the topics of Mellanby's published researches, which also include studies on alcoholism and disease of the thyroid gland, ergotism, the metabolism and transmission of cancer, the control of infections, especially puerperal sepsis and maternal mortality. Nor does it include new probings into some major problems in disease which were in hand at the time of his death. His declared aim was to open up new fields of research, especially of a physiological nature. This was a deliberate attempt to secure relatively more attention for biological objectives in research. He restricted his own interests in the biochemical and chemical aspects of problems he was studying, as he felt that biochemistry was developing rapidly into a special branch of chemistry only too rarely with any direct relation to biological function.

In his book, "Nutrition and Disease"[12], Sir Edward had outlined a plan for combining research in the clinical and laboratory fields; his success in applying his plan on a national scale will, it is hoped, be evident from the foregoing incomplete survey. His success is the more remarkable when it is realized that not only was there a substantial volume of peace-time research initiated and sponsored by the Medical Research Council, but also an enormously increased activity on numerous war-time problems in civilian matters and in all branches of the Fighting Services. The last two reports of the Medical Research Council published while Sir Edward Mellanby was still its secretary contain admirable accounts of these activities.

In nutrition, Mellanby's chosen field of special interest and research, he early achieved international prominence, and in the early 'thirties he was made chairman of the League of Nations International Technical Commission on Nutrition. He was an active member of the Accessory Food Factors Com-

mittee of the Medical Research Council since its inception and its chairman for many years. He contributed in this and other ways to the improvement of health through better nutrition. As a member of the Scientific Food Policy Committee of the War Cabinet and later of the Chief Medical Officer's Committee of the Ministry of Health, he exercised a powerful influence on the medical aspects of food policy in Great Britain. As chairman of the Food Rationing (Special Diets) Advisory Committee he took an important part in the difficult task of deciding how war-time rations should be modified or supplemented for persons with certain diseases.

Research abroad owes much to his influence, and in recent years he visited Africa, India, Australia and New Zealand for the express purpose of advising on research. Earlier he had been to Canada and on other occasions to the United States. In all these countries he had many friends. He took an active interest in the work of the British Council and was chairman of the advisory Medical Panel from its formation in 1942, and he gave unstinting help and encouragement to the Council's medical work; his interest in the *British Medical Bulletin* never flagged, and it was his abiding concern to ensure that this journal conformed to its main purpose of presenting to overseas readers the many aspects of medical research in which British workers have excelled. For many years he was active in the development of medical research in Colonial territories and was chairman of the Colonial Medical Research Committee. Not only did he recognize the great need for the application of medical science, but he also foresaw what has only recently been widely recognized as a major problem, namely, the need for relating the rapidly increasing population to the supply of sufficient food. He insisted that "most of the political, social and economic difficulties in tropical countries are, and will continue to be, biological in nature, and the sooner this fact is recognized the sooner will these difficulties be controlled or dispersed . . . and we can only pray," he said, "that there is sufficient wisdom left among us to use the fruits of science properly"[7].

Those who have known Sir Edward Mellanby and his work can easily add further tributes from their knowledge of other contributions of this great man to the quantity and quality of the life and living of mankind. The illustrations given speak, out of his own mind, of the man, his work, character, ideals and objectives in ways which need no elucidation; indeed, any attempt to do so would be unjustifiable presumption. It is a sign of his influence and calibre that those who knew him best are united in their profound respect and affection for him. Our appreciation of the contribution of his constant partner, Lady Mellanby, must be one of gratitude; and we trust that she, with us, will find comfort in contemplation of his magnificent record of achievement.

B. S. Platt

[1] Mellanby, E., The Hopkins Memorial Lecture, *J. Chem. Soc.*, 713 (May 1948).
[2] Medical Research Council Minute, February 18, 1955.
[3] *Lancet*, p. 309 (February 5, 1955).
[4] Mellanby, E., The Harveian Oration, *Lancet*, ii, 929 (1939).
[5] Mellanby, E., The Huxley Lecture, pp. 12 and 7 (1935).
[6] Medical Research Council Report 1945–8, p. 37.
[7] Mellanby, E., Rede Lecture, pp. 5, 62 and 59 (Camb. Univ. Press, 1939).
[8] Mellanby, E., 13th Stephen Paget Memorial Lecture, "The Fight Against Disease", **27**, pp. 5, 4, 2 (1939).
[9] Mellanby, E., *Quart. J. Med.*, **9**, No. 35 (1916).
[10] Mellanby, E., "A Story of Nutritional Research", pp. 430 and 431 (Williams and Hopkins, Baltimore, 1950).
[11] Mellanby, E., *Brit. Med. J.*, ii, 863 (1951).
[12] Mellanby, E., "Nutrition and Disease" (Oliver and Boyd, Edinburgh, 1934).

Prof. J. K. Parnas

News has been received recently of the death of J. K. Parnas, formerly professor of physiological chemistry in the University of Lwów (Lemberg), known internationally for his fundamental researches in the biochemistry of muscle.

Jakób Karol Parnas was born in Eastern Poland on January 17, 1884, and as a boy was educated in Lwów. He then entered upon an academic career as a student of chemistry, at the Technische Hochschule of Berlin-Charlottenburg. In 1905 he joined the laboratory of Richard Willstätter in Zurich, where as a subject for his Ph.D. dissertation he was allotted the tedious task of preparing the so-called third (or 'amphi') naphthoquinone. It was much to the pupil's credit, and to his teacher's delight, when two years later, after numerous trials with a wide range of metallic oxides, he succeeded in preparing the crystals of this long-sought-after labile compound. Years later this achievement brought him warm praise from Willstätter, who in his autobiography records also the accident which occurred in the course of Parnas's experiments, when a preparation of gold oxide freshly removed from the desiccator exploded in contact with a spatula, and countless particles of gold became lodged in the young experimenter's eye. Although some of the larger particles were removed surgically, smaller ones stayed in the cornea permanently, fortunately without discomfort to the bearer, who in his later years was ever ready to exhibit them to his students and accompany this with a suitable reference to the physiological inertness of gold as a 'noble' metal.

Having thus obtained his doctorate, Parnas removed to Hofmeister's laboratory in Strassburg, where he worked until the outbreak of war in 1914, except for short periods spent on research at the Stazione Zoologica in Naples and in the Physiological Laboratory in Cambridge. The years which he spent with Hofmeister, first as 'assistant' and later as 'dozent', remained in Parnas's memory as his happiest ones, and for Hofmeister himself he preserved lasting devotion and admiration. His first scientific contribution from this laboratory, which he submitted to the *Biochemische Zeitschrift* in 1906, was on the purification, properties and composition of brain cephalin, a subject of which he was very fond but on which he worked only for a few more years.

Soon afterwards, Parnas's interest turned to the intermediary metabolism of animal tissues—more specifically, the physiological significance of the Cannizaro reaction. In 1910 he demonstrated that this reaction, in which two molecules of aldehyde interact to produce one molecule of acid and one of alcohol, is catalysed in the liver by a soluble enzyme which he named 'aldehyde mutase'. The study of this enzyme formed an introduction to Parnas's further work on enzymic processes underlying the intermediary carbohydrate metabolism of tissues, particularly that of muscles. Among his other contributions made at Strassburg, three deserve specific mention: (i) the recognition of the fact that of the two optical isomers of lactic acid, one, namely, L(+) lactic acid, is metabolized in the animal body in preference to the D(−) isomer; (ii) the elaboration of energy requirements for smooth and skeletal muscles, both when resting and during contraction; and (iii) a quantitative study—one of the earliest of its kind—of the relationship between the disappearance of glycogen and the formation of lactic acid in isolated, contracting frog muscles. In the last-

mentioned study, Parnas carried out his experiments partly in collaboration with Richard Wagner; their two names are also linked with the design, a few years later, of the Parnas–Wagner distillation apparatus for the micro-determination of nitrogen.

After the First World War, Parnas returned to his native country and resumed with great vigour his research activities, at first for a short time in Warsaw, and later at the Joannes-Casimirus University in Lwów, where within a few years he succeeded in creating a flourishing centre of teaching and research and in assembling around him a group of devoted and enthusiastic co-workers, often referred to as the 'Parnas School'. Of these, J. Heller (now professor of biochemistry in Warsaw) and W. Mozolowski (now occupying the chair of biochemistry in Gdańsk) shared with Parnas the credit for the discovery of the process of ammonia formation in blood (1924) and in muscle (1927), and for establishing that this ammoniogenesis is due to the deamination of adenylic acid to inosinic acid. Further intense research on the significance of this process in muscular contraction was greatly facilitated by the method for large-scale preparation of adenylic acid developed in Parnas's laboratory in 1932 by his pupil and co-worker, Paul Ostern (who died tragically during the Second World War).

The Parnas reaction, discovered in 1934, established that adenosine triphosphate, the mother-substance of adenylic acid, is directly involved in the enzymic transfer of phosphate groups, from the phosphorylated intermediary products of muscle glycogenolysis, to creatine. This finding, coupled with the Lohmann reaction, formed the basis of much of the later work on the 'chemical linkage' processes, not only in the muscle but also in all other animal tissues, as well as in yeast and bacteria. The 1930's were probably the most active period in Parnas's life. Those who, like myself, had the good fortune to be associated with him in that phase of his activity, will remain filled with admiration for his qualities of leadership, his profound knowledge of chemistry and physiology, his exceptional skill in designing experiments, and last but not least, his almost uncanny encyclopædic memory. This great gift enabled Parnas to master several languages, to retain faultlessly the names and faces of countless students, to quote page-long excerpts of Greek and Latin poetry, which he learnt as a boy, and to shower upon his pupils scientific facts and chemical formulæ.

As a teacher, Parnas was most stimulating, and his text-book of biochemistry, written in Polish, is a masterpiece. Sometimes, carried away by his enthusiasm while lecturing, in exposing the intricate mechanisms of chemical reactions (which he invariably illustrated by the most complicated and ingenious demonstrations), he would forget completely that but few in his student audience were capable of following him. A man of exceptionally powerful physique, he used to amuse the medical students by pointing out that there are no data in the existing tables for computing the basal metabolism of a person of his size and weight. Yet, this massive frame did not prevent him from constructing and handling the most delicate instruments and apparatus.

Parnas's many friends in Britain and elsewhere will mourn the passing of this exceptional man.

T. Mann

NEW FELLOWS OF THE ROYAL SOCIETY

At the meeting of the Royal Society on March 17, the following were elected to fellowship:

Prof. D. R. Bates, professor of applied mathematics, The Queen's University, Belfast, distinguished for his contributions to theoretical atomic physics and its application to the interpretation of phenomena in the earth's atmosphere.

E. J. H. Corner, lecturer in botany, University of Cambridge, distinguished for his researches on fungi and on tropical floras.

Prof. A. H. Cottrell, professor of physical metallurgy, University of Birmingham, distinguished for his research work, both theoretical and practical, concerning the mechanical properties of metals.

Prof. S. Devons, professor of physics, Imperial College of Science and Technology, University of London, distinguished for his researches in nuclear physics, including the investigation of short-lived states of nuclei.

Prof. A. W. Downie, professor of bacteriology, University of Liverpool, distinguished for his contributions to bacteriology and virology and especially into the viruses belonging to the pox group.

Prof. K. C. Dunham, professor of geology, University of Durham, distinguished for his petrological researches, his work on the genesis of ore deposits, and on the stratigraphy of the north of England.

Dr. D. J. Finney, reader in statistics, University of Aberdeen, and director of the Agricultural Research Council's Unit of Statistics, distinguished for his work in the development and application of statistics to biological problems, especially in the field of bioassay.

Dr. A. Fleck, chairman, Imperial Chemical Industries, Ltd., distinguished for his contributions to chemical technology and for his pioneering work on the radioactive elements.

Prof. K. J. Franklin, professor of physiology, St. Bartholomew's Hospital Medical College, London, distinguished for the application of X-ray cinematography to physiological problems, for work on veins and vascular reflexes, and the history of physiology.

Prof. W. P. Hawthorne, professor of thermodynamics, University of Cambridge, distinguished for his researches in the combination of thermodynamics and hydrodynamics on which the design of high-speed heat engines is based.

Prof. D. H. Hey, Daniell professor of chemistry, King's College, University of London, distinguished for his original contributions to the study of free radicals of short life as intermediates in chemical reactions, and to synthetical organic chemistry.

Sir Harold Himsworth, secretary of the Medical Research Council, distinguished for his contributions to clinical investigation, and especially for researches

into the etiology of diabetes mellitus and liver necrosis.

A. F. Huxley, assistant director of research in physiology, University of Cambridge, distinguished for fundamental discoveries concerning the conduction of impulses in nerves, and for developing new methods for the study of nerves and muscles.

Prof. R. W. James, professor of physics, University of Cape Town, distinguished for investigations of the structure of matter through the use of X-rays, and particularly for his studies of thermal motions of atoms in crystals.

Dr. D. Lewis, head of the Genetics Department, John Innes Horticultural Institution, Bayfordbury, Hertfordshire, distinguished for his researches on the genetics and physiology of pollination.

Dr. J. W. Linnett, lecturer and demonstrator in chemistry, University of Oxford, distinguished for his work on molecular structure and on the physical chemistry of combustion and flame propagation.

Prof. A. C. B. Lovell, professor of radio astronomy, University of Manchester, distinguished for his contributions to radio astronomy and in particular for his work on the detection and investigation of meteors by radio methods.

Prof. O. E. Lowenstein, Mason professor of zoology and comparative physiology, University of Birmingham, distinguished for his work on the comparative physiology of the vertebrate labyrinth.

Dr. R. A. Lyttleton, lecturer in mathematics, University of Cambridge, distinguished for his original contributions to theoretical astronomy and astrophysics and for his mathematical researches on rotating liquid masses.

Dr. A. G. Ogston, lecturer in biochemistry, University of Oxford, distinguished for the application of physicochemical principles and methods to biological problems.

Dr. G. Pontecorvo, reader in genetics, University of Glasgow, distinguished for his contributions to genetics, especially by his studies of gene action, gene organization, and systems of variation in fungi.

Dr. J. A. Ramsay, lecturer in zoology, University of Cambridge, distinguished for his analysis of factors controlling the water balance in animals and for the elegance of the micromethods he has devised.

Dr. F. C. Tompkins, reader in physical chemistry, Imperial College of Science and Technology, University of London, distinguished for his experimental and theoretical contributions to the study of physical and chemical adsorption, and the thermal decomposition of ionic solids.

Prof. A. G. Walker, professor of pure mathematics, University of Liverpool, distinguished for his work on the foundations of relativity theory, and for important contributions to differential geometry, including the theory of harmonic spaces and the theory of fibre bundles.

Prof. G. P. Wells, professor of zoology, University College, London, distinguished for his studies relating structure and function to mode of life of invertebrate animals, particularly of polychætes.

NEWS and VIEWS

Royal Geographical Society : Awards

H.M. the Queen has been pleased to approve the award of the Royal Medals of the Royal Geographical Society as follows : *Patron's Medal*, to Dr. John K. Wright, lately director of the American Geographical Society of New York, for services in the development of geographical research and exploration ; *Founder's Medal*, to Commander (L) C. J. W. Simpson, leader of the British Expedition to North Greenland, 1952–54. The Council of the Society has made the following awards : *Victoria Medal*, to Sir John Russell, for his studies of soils and agriculture and for services to geographical education ; *Murchison Grant*, to Dr. H. C. K. Henderson, lecturer in economic geography, Birkbeck College, London, for studies in economic geography ; *Back Grant*, to Captain O. C. S. Robertson, for his journey through the North West Passage in one season in the icebreaker *Labrador* ; *Cuthbert Peak Grant*, to D. G. A. Bunker, for geographical exploration and mapping in south-west Arabia ; *Gill Memorial*, to Dr. Marjorie Sweeting, lecturer in geography, University of Oxford, for contributions to the physiography of limestone areas ; *Mrs. Patrick Ness Award*, to Dr. E. F. Roots, senior geologist, Norwegian–British–Swedish Antarctic Expedition, 1949–52.

University Grants Committee : New Members

The Treasury has announced the appointment of four new members of the University Grants Committee to take the place of retiring members, and of two additional members, bringing the total up to eighteen. The retiring members are Lord Adrian, Dr. J. W. Cook, Prof. G. W. Pickering and Sir David Hughes Parry. The new members are Prof. R. S. Edwards, professor of economics with special reference to industrial organization in the University of London ; Dr. Willis Jackson, director of research and education, Metropolitan-Vickers Electrical Co., Ltd. ; Prof. R. H. Matthew, professor of architecture in the University of Edinburgh ; Prof. P. B. Medawar, Jodrell professor of zoology and comparative anatomy, University College, London ; Prof. A. Robertson, Heath Harrison professor of organic chemistry, University of Liverpool ; and Sir George Thomson, master of Corpus Christi College, Cambridge.

New Nature Reserves

The new nature reserve at Axmouth – Lyme Regis undercliffs in Devon, declared by the Nature Conservancy on March 16, forms the largest and most important landslip area on the coast of Great Britain. There have been periodic slips from the sixteenth century onward of the chalk and underlying greensand on the Gault and Lower Lias clay which dip towards the sea, the most spectacular being that on Christmas Day, 1839, when nearly 8 million tons of rock subsided from a cliff 375 ft. high, leaving a chasm half a mile long and 200–400 feet in width. The new reserve, which extends along some five miles of coast and covers 708 acres, is primarily of geological interest but has a wide variety of soils and is almost completely covered with vegetation, notably a well-grown natural ashwood. Interesting birds and butterflies are also to be found. The Con-

servancy hopes to arrange for the improvement of the public foot-path through the reserve as a step towards the proposed South Devon Coastal Path; but permits will be required to undertake research, to collect specimens of animals or plants or to visit parts of the reserve away from the footpath, and applications for such purposes should be addressed to the Conservancy at the Furzebrook Research Station, Wareham.

On March 16 also the Conservancy declared an extension of 200 acres to the existing Scolt Head Nature Reserve, bringing the whole of the Island, some five miles long, within the reserve. The Island has become a classic site for the study of coastal erosion, sand and shingle bank formation and the development of salt marshes. There is a well-established breeding colony of Sandwich terns, and during the autumn and spring migrations many rare birds have been recorded. The Island's main botanical interest lies in its wide variety of marine and other plant communities on shingle beach, sand dune and salt marsh. Access will not be restricted; but permits will be required to collect specimens of animals or plants within the reserve.

Astronautica Acta: New Journal of Astronautics

THE first number of a new quarterly entitled *Astronautica Acta*, the official journal of the International Astronautical Federation, has recently appeared, published by Springer-Verlag, of Vienna, and I. R. Maxwell and Co., Ltd., of London, Paris and New York (1, No. 1; 1955. Pp. 60. Annual subscription 62*s*. or 8.60 dollars). The journal is edited by Prof. F. Hecht, of Vienna, assisted by an editorial board consisting of W. von Braun (United States), A. Eula (Italy), J. M. J. Kooy (Holland), E. Sänger and K. Schütte (Germany), L. R. Shepherd (Great Britain) and J. Stemmer (Switzerland), to any of whom contributions may be sent. The first number opens with a general statement on the feasibility of flight through outer space by Prof. von Braun, and contains four articles on various aspects of astronautics. I. Sänger-Bredt makes a critical examination of the experimental methods which have been applied to the problem of understanding the fundamental nature of chemical combustion processes and discusses their results. H. Strughold writes on conditions in those parts of the atmosphere that are physiologically similar to outer space. D. F. Lawden discusses the optimal programming of rocket thrust direction with the view of achieving the maximum energy increment in the pay-load over a given period of time; this is of interest in the problem of the most economical method of escaping from an orbit. Finally, J. Eugster shows that the major effects of cosmic rays on photographic plates are also detectable by means of dyes; this is of practical importance in biological work where the use of photographic plates is unsuitable. The format and printing are of the fine quality that one expects of the house of Springer. It is to be hoped that the journal will obtain the support it deserves and that the high standard set by its first part will be maintained.

Strategy of Research

IN a paper in *Research*, the Earl of Halsbury, managing director of the National Research Corporation, emphasizes that there is a great wealth of latent research talent in the universities and public laboratories partly engaged on pure research of a comparatively low order of significance and available for redeployment into basic research of a higher order (*Research*, **7**, No. 12; December 1954). One condition for this is that a number of major targets in applied research should be selected for general attack. The administrative machinery of government science is, through its laboratories and its grant-aiding and development contractual procedure, adequate to cope with any demands made on it, while, through the medium of research associations, some initiative can be taken publicly or semi-publicly in specifying the sort of problems in applied science which could form the basis for civilian development contracts financed at the public expense. The major contribution in initiative must come from industry itself, however, and there can be no substitute for this. In Lord Halsbury's opinion, where industry fails to show initiative, this springs less from a conflict of view between commercial and technical management than from their common and reciprocal failure to act in concert on the basis of a rational appreciation of the part that each has to play. This failure of the rational is linked to a national preference for the intuitive approach to the taking of decisions. It cannot be expected to change rapidly; its study by the methods of the social sciences is necessary if it is to be understood more deeply.

Physical Basis of Temperature Regulation in Man

DURING the past fifteen years there has been a steadily increasing interest among physiologists in the nature of the mechanisms associated with human thermo-regulation. In a paper entitled "Physical Basis of Temperature Regulation in Man", Prof. E. M. Glaser, of the Department of Physiology, University of Malaya, Singapore, presented to the Pan-Indian-Ocean Science Congress held last year in Perth, Western Australia, an appraisal of the present situation in this field. He pointed out that any thermostatic system is imperfect in that it must have a finite load error. Owing to the large thermal inertia of the body, a mechanism concerned only with the maintenance of an approximately constant deep-body temperature would be at best inefficient and at worst unstable. The performance is, in fact, profoundly affected by the derivation of thermal information from the surface of the body as well as from the deeper tissues. The resulting control is less precisely thermostatic, as is shown by the considerable variations in deep-body temperature which it permits, but has the virtues of increased flexibility and very much more rapid response to changes in environmental conditions. It may be regarded as primarily controlling thermal balance (homeothermokatametry) rather than deep-body temperature (homeothermy). The physiological responses involved in long-term acclimatization to heat and cold present a problem unique in the field of thermostatics, since the continued operation of responses of one sort appears to cause changes in the sensitivity of the whole control mechanism.

Scientific Approach to Cancer

THE March issue of the *Practitioner* is devoted mainly to the cancer problem, and besides an article on "Our Present Understanding of the Cancer Cell" by Prof. A. Haddow, there are review articles on the place of surgery (H. Atkins), radiotherapy (A. P. Wood and R. Morrison), chemotherapy (Edith Paterson), endocrinology (B. J. Kennedy) in treatment, and, because of its current high incidence,

an article (Sir Clement Price Thomas) devoted to carcinoma of the lung. All these summarize the present position very clearly, and it is noteworthy that all the authors foresee the eventual therapeutic solution in some form of chemotherapy. Prof. Haddow's summary of some of the fundamental experimental work is likely to be of interest to many readers of *Nature*, and it can be heartily recommended as giving in small compass an excellent idea of the main scientific approaches to the problem. It shows how we are beginning to regard the first ('initiation') stage of chemical carcinogenesis as being a combination of the chemical or its metabolites with one or more specific tissue constituents, and the second ('promoting') stage as one of continued proliferation or delayed maturation of the 'initiated' cells, with the final stage (neoplasia) emerging after protein deletion. One current view is that the cancer cell is such because it has lost key proteins essential for the control of growth. With the plethora of facts, attempts to arrive at a unifying hypothesis showing how the diverse and very numerous 'initiating' agents all have the same end result is becoming essential. What is the common factor in carcinogenesis induced by aromatic amines, polycyclic hydrocarbons, ionizing radiations, viruses, hormones and even prolonged tissue culture of some normal cells? This article adequately condenses much of the main evidence which has to be embraced in such a hypothesis. Attention is directed to the recrudescence of interest in tumour immunology, though without discussion. The present writer believes that future articles of this type will perforce discuss this subject more and more, for he has himself recently put forward evidence which supports Prof. Haddow's evaluation of its being "the most logical of all approaches".

Radioiodinated Human Serum Albumin

The Radiochemical Centre (White Lion Road, Amersham, Bucks) can now supply human serum albumin which has been iodinated with radioactive iodine-131 to hospitals and research institutions in the United Kingdom in the same way as it supplies iodine-131. The product (Code No. 1*B*.17) is in an isotonic saline solution (*p*H 9·0–9·2), which is sterile and free from pyrogens, and is packed in 10-ml. rubber-capped multi-dose bottles. The specific activity is not less than 5 mc./mgm. albumin, and the minimum concentration is 100 mc./ml. solution. The protein is iodinated uniformly, and the amount of iodine present is less than 0·2 per cent of the weight of albumin. The active iodine is firmly bound to the protein molecules, and not more than 2 per cent of the total activity is in the form of free iodide at the time of dispatch. Particular care is taken to avoid denaturation, and the product cannot be distinguished from the original albumin by electrophoresis. The product is supplied in standard packages containing either 0·2 mc. (£3) or 1·0 mc. (£5), larger quantities up to 5 mc. being available by arrangement (£5 per mc.). The human albumin is supplied by the Ministry of Health free of charge, and the price of the iodinated material includes only the cost of manufacturing and testing.

Effects of Radiations on Human Populations

In an address delivered on January 11 to the California Institute of Technology, Dr. A. H. Sturtevant discussed the hazards of the increase in high-energy radiations to which human populations are already exposed as a consequence of atom- and hydrogen-bomb tests and medical and other activities. He distinguished the two types of hazards: those to the exposed individuals and those to their descendants, and emphasized the appalling ignorance in which we are as to the long-term biological effects of radiations. Extrapolating from *Drosophila* to man, the present increase of radiation due to 'fall-out' from bomb tests would be responsible for the conception of 1,800 more individuals per year heterozygous for recessive lethals in the whole world. Dr. Sturtevant stressed that, in view of its social significance, scientists must try to get some idea of how much of what may be happening, and to how many people.

School Nature Study Union

The first number of the fiftieth volume of *School Nature Study*, the journal of the School Nature Study Union, which appears in a new and attractive form, contains details of new activities by the Union (George Philip and Son, Ltd., London. 2*s*. 6*d*.). Besides the usual meetings and excursions which are organized in and around London, some provincial areas are showing interest in the Union's activities, and there is a possibility of a branch being formed in the Midlands. The journal contains some useful hints by John Sankey, assistant warden of the Juniper Hall Field Centre, on the ways of taming wild animals like foxes and badgers, an article by E. T. Cluff on the behaviour of 'winter gnats', and other articles and reports on a number of conferences and meetings.

Tanganyika Agricultural Corporation

The work in Tanganyika of the Overseas Food Corporation is to be continued by a new organization, the Tanganyika Agricultural Corporation, which will come into being on March 30. It will operate in the areas taken over from the Overseas Food Corporation and will be financed for this purpose until September 1957 by a Colonial Development and Welfare grant from the British Government. The new Corporation will also be invited by the Government of Tanganyika to assist in carrying on the Rufiji Basin reconnaissance survey which is at present in progress under the ægis of the United Nations Food and Agriculture Organization. In particular, it will be asked to establish the trial farms that are being planned as part of this investigation. In addition, consideration is being given to other agricultural development projects which might with advantage be undertaken by the Corporation, by agreement with the Government.

Physical Society's Exhibition

The Physical Society's annual Exhibition of Scientific Instruments and Apparatus will be held in the Royal Horticultural Society's New Hall, Greycoat and Elverton Streets, London, S.W.1, on the following dates: April 25, 10.30 a.m.–8 p.m. (Fellows and press only, 10.30 a.m.–2 p.m.); April 26 and 27, 10 a.m.–8 p.m.; and April 28, 10 a.m.–5 p.m. The discourses this year will be as follows (each one at 6.15 p.m.): April 25, the free electron as a tool in scientific research, by Mr. M. E. Haine (Associated Electrical Industries, Aldermaston); April 26, memory systems in the brain, by Prof. J. Z. Young (Department of Anatomy, University College, London); and April 27, recent developments in luminescence and its applications, by Dr. G. F. J. Garlick (Department of Physics, University of

Birmingham). As in previous years, the Society is publishing a "Handbook of Scientific Instruments and Apparatus" in connexion with the Exhibition (6*s*., or 7*s*. by post). All inquiries should be sent to the Society at 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

University of Birmingham : Appointments

THE title of reader in organic chemistry in the University of Birmingham has been given to Dr. E. J. Bourne, senior lecturer in organic chemistry. The following appointments have recently been made in the University : Dr. B. G. Gowenlock, to be lecturer in chemistry ; G. Webster, Edward Cadbury Fellow in archæology, to be staff tutor in archæology ; and S. J. Lyle, to the J. Lyons fellowship in analytical chemistry. The title of University research fellow has been given to the following during the tenure of their present posts : Dr. H. Spedding, of the British Cotton Industry Research Association, who is working in the Department of Chemistry, and Dr. J. S. Howell, who is working in the Department of Pathology, for the Birmingham Branch of the British Empire Cancer Campaign Committee.

Belgian Physical Society : Officers

AT the annual general meeting of the Société Belge de Physique, held on February 19, the following officers were elected : *President*, Prof. P. Swings (Liège) ; *Vice-Presidents*, Prof. W. de Keyzer (Ghent), Prof. J. Delfosse (Louvain) and Prof. G. A. Homes (Brussels) ; *Secretary General*, Dr. M. C. Désirant (A.C.E.C. Physics Research Laboratory, Charleroi).

The Night Sky in April

FULL moon occurs on April 7d. 06h. 35m., U.T., and new moon on April 22d. 13h. 06m. The following conjunctions with the moon take place : April 10d. 03h., Saturn 6° N. ; April 20d. 05h., Venus 7° S. ; April 25d. 02h., Mars 0·7° S. ; April 28d. 02h., Jupiter 3° N. In addition to these conjunctions with the moon, Mars is in conjunction with Aldebaran on April 25d. 23h., Mars being 6·4° north of Aldebaran. Mercury, in superior conjunction on April 23, is unfavourably placed for observation during the month. Venus rises at 4h. 40m., 4h. 20m. and 4h. on April 1, 15 and 30, respectively, and will be visible for a short time before sunrise. Its stellar magnitude varies from −3·5 to −3·4, and the visible portion of the illuminated disk from 0·756 to 0·835 ; this increase does not compensate for the planet's recession from the earth—from 107 to 124 million miles between April 1 and 30—so that there is a small decrease in brightness. Mars sets about 22h. 30m. during the month and has an eastward movement in Taurus ; its close approach to Aldebaran on April 25 has been pointed out. Jupiter remains visible until the early morning hours, its times of setting being 2h. 55m., 2h. 05m. and 1h. 10m. at the beginning, middle and end of the month, respectively, and is a conspicuous object in Gemini ; in the third week of April it is a little south of x Geminorum ; its stellar magnitude varies from −1·8 to −1·6, the decrease in brightness being due to its distance from the earth increasing from 465 to 508 million miles during the month. Saturn rises at 22h., 21h. and 20h. on April 1, 15 and 30, respectively, and has a retrograde movement in Libra ; its brightness increases by 0·2 mag. during the month, owing to its distance from the earth decreasing from 847 to 828 million miles. Only one occultation of stars brighter than magnitude 6 occurs in April, observations being made at Greenwich : April 2d. 22h. 42·1m., *h* Leo. (*D*), *D* referring to disappearance. The Lyrid meteor shower attains a maximum on April 21 ; the radiant of this shower is at R.A. 18h., Dec. 33° N.

Announcements

THE Baekeland Memorial Lecture of the Plastics and Polymer Group of the Society of Chemical Industry will be given in the Royal Institution, London, W.1, on June 2, by Dr. C. E. K. Mees, who will speak on "Leo Hendrik Baekeland and Photographic Printing Papers".

A MEETING is being held under the auspices of the Institute of Biology on April 15 at the Polytechnic, Regent Street, London, W.1, to discuss the place of biology in technical colleges. Speakers will include representatives of industry, agricultural research and the Ministry of Education, an external examiner of the University of London and several lecturers from technical colleges. The meeting is open to all interested, and further information can be obtained from the General Secretary, Institute of Biology, Tavistock House South, Tavistock Square, London, W.C.1.

THE essay subjects for this year's *Endeavour* prizes of the British Association for the Advancement of Science will be as follows : the earth's magnetism ; man-made fibres ; climatic changes ; scientific aids to food supply ; respiration ; and new metals for engineers. The essays must be sent in by June 1 and should not exceed four thousand words. Competitors must be less than twenty-five years of age, and the prizes will be 50, 25 and 15 guineas respectively, with two special awards of 5 guineas to those less than eighteen. Further information can be obtained from the Assistant Secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1.

THE Textile Institute is offering a three-year scholarship, of total value £950, which is open to a man of British nationality, and less than twenty-four years of age, to enable him to pursue a three-year course in textile technology at a university, or equivalent, level. The Institute is also offering two new scholarships, to be known as the Peter Coats Scholarships, for young men of about school-leaving age to study for a college diploma or other qualifications in subjects connected with the cotton industry. The scholarships will be worth not more than £100 a year, tenable for two or three years in a British technical college. The closing date for entries for all these awards is April 30, application forms and further information being obtainable from the General Secretary, Textile Institute, 10 Blackfriars Street, Manchester 3.

FROM £8,000 of the United States Counterpart Funds for economic aid, the Ministry of Agriculture and Fisheries is offering a number of postgraduate scholarships during the academic year 1955–56 for vocational training in the following subjects : agricultural economics, farm management, estate management, and land economics and land use. The scholarships will be worth £400–800, free of income tax, plus all compulsory fees and other expenses, and are open to British subjects resident in the United Kingdom. Application forms, to be returned by April 30, and further information can be obtained from the Secretary, Ministry of Agriculture and Fisheries, 1–4 Cambridge Terrace, London, N.W.1.

ORGANIZATION OF APPLIED RESEARCH

EIGHT annual conferences on the administration of research have been held in recent years in the United States. The interest in research administration is growing with its importance, and technical assistance missions sponsored by the Organization for European Economic Co-operation visited research establishments in Western Europe in 1951, and the United States and Canada in 1952. Their observations and conclusions have been published in three volumes under the general title "The Organization of Applied Research in Europe, the United States and Canada" (see *Nature*, **174**, 778; 1954).

In spite of its manifest importance—it is reported that the United States alone is now spending three billion dollars annually on research—no conference on research organization had been held at an international level until that which took place in Nancy during October 11–15, 1954, arranged by the European Productivity Agency. Moreover, it is perhaps significant, and possibly strange to British ideas, that according to one delegate such a conference could not have been convened five years earlier. The conference was distinctly European, with about one hundred delegates from Western Europe and with American representatives as observers. As such, the many and varied expressions of opinion referred largely to the problems and difficulties of Western Europe.

Three separate approaches to the central theme were made on each of three succeeding days. The first day was devoted to the subject of "The Practical Organization of Research"; the second to "The Human Factor in Research and Team Work"; and the third to "The Dissemination of Results of Research and their Implementation". Each day's papers and discussion were summarized by a series of 'conclusions' which, it is hoped, will provide springboards for action in the different countries represented.

Papers at the first session were delivered by Dr. L. Henry (Belgium), Dr. D. W. Hill (Great Britain) and Prof. M. Letort (France). To some extent the discussion inevitably tended to centre around the relations between universities and industry—a major problem which has not yet been solved in Europe. It was generally considered that, while universities and industry must be brought closer together, each recognizing and, indeed, catering for the needs of the other, the American solution of extensive applied research projects in universities has progressed too far in one direction, to the possible detriment of the pure research function of the university. This led naturally to a discussion of how much applied research a university can undertake, in order to assist industry and strengthen its teaching function without undermining its research function.

Attempts to define the problem resulted, despite a plea from the chairman, Dr. A. King (Great Britain), in a discussion of the meanings of pure and applied research. In this connexion a phrase used by Prof. Maurice Letort (France) sticks in the memory: in pleading for a recognition that applied research could often be sufficiently fundamental to satisfy the strictest purists, he described the kind of applied research which could usefully be done in universities, and which is already the main occupation of central research organizations, as "directed basic research" —that is, fundamental research directed to a useful end. It was Prof. Letort, too, who probably gave the last word on this subject. Expressing his conviction that the dichotomy of pure and applied research is, in fact, non-existent, he pointed out that, since there must be some choice of subject, the academic research worker should choose a field with a big hinterland rather than one which would yield immediate technical results.

The conclusions of the session reflected the discussion, especially with their insistence upon the need for applied research, the interdependence of academic research and industrial development, the need to preserve the freedom of academic research, and the desirability of governments assisting research of all kinds both directly and by fiscal policies which encourage research expenditure.

The discussion on the second day was remarkable in that human factors had never before been discussed at a conference in Europe, and no less so in that the British delegates listened intently but made only one very brief contribution to it. It was evident that the human problems of Continental Europe are not those either of Great Britain or the United States. The chairman, Mr. V. Lasareff (Organization for European Economic Co-operation), emphasized what is perhaps not generally recognized, namely, that, in applied research, productivity depends more upon the human factor than upon any other. The importance of the human factor can therefore scarcely be over-estimated. There can be little question that, of all the problems of research, the human ones, particularly the reconciliation of the interests of the community with those of the individual, present the widest differences between countries. For this reason, the last conclusion of the day, though apparently the most innocuous, may in the long run prove to be the most effective. This conclusion adopted a suggestion from Mr. Lasareff that the participating countries should compare their methods for selecting and evaluating staff. This should prove a relatively simple, but possibly very rewarding, task for the Organization for European Economic Co-operation.

After recognizing the importance of human problems in research, other conclusions directed attention to the need to provide both prestige and material satisfaction for the research worker, to the need for security, to the recognition of the value of research training for high industrial positions, and to the desirability of selecting research directors as much for their aptitude for leadership as for their scientific knowledge. More controversial, perhaps, was a conclusion that education from school-days onwards should aim at emphasizing the importance of research and preparing young people for teamwork and its discipline.

An absorbingly interesting paper on the evening of the second day, by Dr. J. W. Barker (United States), outlined the conception, philosophy and practice of the Research Corporation of New York, and introduced the subject of the patenting of research results. This was followed on the third day by an exposition of his views by Signor L. Morandi, vice-president of the Montecatini Company of Italy. The subsequent discussion on patents, though interesting, could scarcely be said to add much to the vast experience

gained by the Research Corporation of New York and so fully put at the disposal of the conference by Dr. Barker.

The remainder of the discussion on the third day was largely concerned with the dissemination of research results. Documentation methods were reviewed in detail, and it was concluded that if efficiently pursued they will largely meet the needs of science and technology, but that the conventional methods do not fit the demands of the smaller firms. A recommendation was therefore adopted that the European Productivity Agency should encourage study designed to solve this aspect of the problem. On a wider approach, it was concluded that the knowledge of the impact of research on a dynamic civilization should be diffused as widely as possible. As Dr. J. S. Whitehead (Great Britain) pointed out in his paper, it is desirable to establish a climate of public opinion favourable to science, in order to ensure its widest application in national life. Such a climate, when established, affects influential people —those who have the direction of affairs—so that they take decisions in line with the needs of science.

To the present writer, at least, it was a matter of regret that more was not said on the implementation of the results of research, for this is a crucial point to which a whole conference might well be devoted. We are commonly told that only a small proportion of research results are capitalized, and that many research organizations could now be well employed ensuring the application of past results for the benefit of industry, rather than piling up new ones to be cast into the limbo with the old. It would be interesting to discuss whether this is true or not, and if so, why. Are there multitudinous results potentially valuable to industry, available and unused? If so, is it the fault of industry or research? Is it the cost of development or the fear of obsolescence? Or is it fiscal policies or innate conservatism, either on the part of industry or of its customers—the public? It is gratifying to know that the Applied Research Division of the European Productivity Agency is now planning a preliminary survey on the development of inventions. Its report, when available, might well form the basis of a future conference.

As was pointed out during the conference, research has been revolutionized during the past twenty-five years. No greater evidence of this could be forthcoming than the holding of such a meeting. Nevertheless, it is to be hoped that none of the delegates believes the conference to have been an end in itself. It was an opportunity for sharpening wits, comparing notes, receiving new points of view—all with the object of returning to the various countries represented to try them out in practice. For, when all is said and done, research organization is not yet a science but an art, and an empirical art at that, so that despite the conclusions no one is likely to dispute the wise words of Prof. M. Letort, "No authoritarian measure or administrative rule can create that confidence and goodwill which are the essential conditions of fruitful collaboration", which is the basis of successful research. With this background, the delegates naturally accepted a final conclusion that a similar conference dealing with the aspects of co-operation in research should be held in a year or two's time.

It would be ungracious to conclude this report without a reference to the excellent arrangements made for the conference by the European Productivity Agency and the University of Nancy. The success of the occasion was due in no small measure to the meticulous organization; and the gratitude of the participants will be directed especially to the rector of the University, Dr. J. Capelle, who also acted as secretary of the conference and who was unsparing in his efforts on their behalf.

D. W. Hill

AERATION IN INDUSTRIAL FERMENTATIONS

ON January 12 the Society for Applied Bacteriology and the Microbiology Group of the Society of Chemical Industry held a joint meeting to discuss "Aeration in Industrial Fermentations". Dr. L. A. Allen was in the chair. Both the microbiological and the physical aspects of the subjects were considered, four papers being given and a short film shown.

In the opening paper, by A. L. Downing and G. A. Truesdale, Mr. Downing described some factors affecting the rate of solution of oxygen in water. The data were obtained from laboratory experiments designed to provide information about re-aeration in a polluted estuary. Relatively small changes in rate of solution of oxygen, expressed as an exit coefficient, resulted from the action of mixing currents or of air-streams forced tangentially over the surface, provided that the surface remained largely undisturbed. Increasing the rate of mixing beyond the point at which vortices were formed caused a rapid increase in exit coefficient, high rates of solution being ultimately attained. Similarly, the exit coefficient increased rapidly as the surface was increasingly disturbed by air-streams having velocities exceeding a critical value equivalent to 6–7 m./sec. at 10 m. above the surface. Increasing the height or frequency of waves, generated mechanically, caused an approximately linear increase in exit coefficient. Under different conditions of surface agitation the exit coefficient increased linearly with increasing temperature in the range 0–35° C. The mean value of the temperature coefficients of the exit coefficient (defined as the increase in exit coefficient expressed as a percentage of the value at 20° C. per deg. C. increase in temperature) was 2·37. Films of oil on the surface caused little effect until their thickness exceeded 10^{-4} cm. Except when fracture of the film occurred, the exit coefficient was steadily reduced as the thickness was increased from 10^{-4} cm. to 10^{-1} cm. Soluble surface-active agents, on the other hand, caused reductions in rate of solution which increased with increasing concentrations up to 1·0 p.p.m. but which tended to a limiting value.

The mechanics of bubble formation was then discussed by Mr. R. H. Bowers, who prefaced a description of his experimental work with a review of data obtained by other investigators. Datta and his co-workers showed that the measured size of bubbles issuing from a single open-ended tube, at low rates of flow of gas, agreed approximately with a theoretical formula derived by equating surface tension and buoyancy forces. As the rate of flow of gas was increased, the bubbles became larger. Van Krevelen has suggested a mechanism from which expressions for the size of both very large and small bubbles can be derived. In many industrial fermentations high flows of gas are required, and, if a simple perforated sparger is used, large bubbles are formed, which can lead to poor aeration. Bubbles produced from porous

diffusers having a large number of orifices and a low rate of flow through each are in some cases smaller than would be predicted from the theoretical equations. A mechanism to account for this has been suggested and confirmed experimentally by Pattle. The properties of the liquid have a pronounced effect in these cases. If a mycelium is built up during fermentation, bubbles become trapped and coalesce. In Mr. Bowers's experiments the rate of absorption of oxygen from bubbles formed with a porous ceramic plate was reduced by a factor of 20 by 2 per cent of paper pulp added to simulate mycelium. This factor was reduced to approximately 7 by agitating the liquid above the plate with a turbine-type stirrer. In an apparatus in which dispersion of the gas was brought about by the mechanical agitator itself, the effect of the paper pulp was reduced still further to a factor of about 2.

Mr. P. E. Sawyer presented a paper by Prof. F. H. Garner and himself on surface-active effects within gas bubbles. The presence of surface-active agents in solution may appreciably influence the behaviour of rising gas bubbles owing to the formation of an adsorbed film at the bubble interface. The principal effect of such an adsorbed interfacial film is to modify the hydrodynamic properties at the gas–liquid interface. Normally the interface between a rising bubble and a liquid permits the transmission of viscous shear across it, resulting in the formation of toroidal circulation currents within the bubble. The drag exerted by the liquid on a circulating bubble is lower than that exerted if the bubble acts as a solid spheroid, and the velocity of ascent of the bubble is thus increased. The presence of a surface-active agent in the liquid may produce a semi-rigid or rigid structure at the interface which resists the transmission of shear and may inhibit or completely suppress circulation.

Mass transfer between a rising bubble and a liquid is also dependent on the character of the interfacial film. Internal circulation is accompanied by a considerable reduction in the resistance to mass transfer in both phases. Thus an adsorbed film will reduce mass transfer-rates by inhibiting circulation; in addition, the film may itself constitute a resistance to mass transfer, possibly by molecular interaction or by mechanical obstruction. The presence of surface-active agents may have an important secondary effect upon the path and shape of a rising bubble. Over a certain velocity-range bubbles normally rise with a spiral motion; surface contamination, however, changes this into a zig-zag motion in one plane. The reduction in surface tension produced by surface-active agents may also lead to changes in the shape of the bubble and to an increased tendency to oscillation.

The effects of certain variable factors on the formation and behaviour of gas bubbles in water, some of which had been referred to by the speakers, were strikingly demonstrated, in slow motion, in a short film. The effects of varying the rate of flow of gas, the diameter of the hole from which the bubbles were formed, and the motion of the water were shown. Dyes injected into the liquid or polarized light were used for illustrating the characteristics of the fluid dynamics around the bubble.

Dr. G. N. Rolinson dealt with the effects of aeration on fungal metabolism. One of the striking differences between moulds and bacteria is that there are no anaerobic moulds. It is extremely doubtful whether any growth takes place when fungi are completely deprived of oxygen. Aeration is frequently a limiting factor in fungal cultures, increased aeration increasing both the amount and rate of growth, and increased aeration frequently results in an increased rate of respiration, since a more extensive respiratory mechanism is synthesized. The respiratory quotient of mycelium grown under conditions of high aeration may be more than double that of mycelium grown under low aeration. One respiratory mechanism developed in response to the level of aeration appears to be the cytochrome system. Mycelium of *Penicillium chrysogenum* oxidizes lard oil rapidly when grown under conditions of high aeration, but only slowly when grown under conditions of low aeration. High rates of aeration are essential for high yields of penicillin. Maximum rate of penicillin production by washed mycelium of *P. chrysogenum* has been found to be dependent on the mycelium being permitted to respire at its maximum rate. This is similar to effects observed in citric acid production whereas, in contrast, the maximum production of α-amylase occurred when the rate of respiration was below the maximum. In addition to the yeasts, many of the Mucors and Fusaria also carry out vigorous alcoholic fermentation when deprived of air. Under aerobic conditions, alcoholic fermentation is depressed, and so also is the rate of glycolysis. This, the Pasteur effect, is probably caused by a lack of inorganic phosphate under aerobic conditions. Aeration may also effect metabolism by sweeping away carbon dioxide which might otherwise be assimilated.

The subjects raised in the lively discussion following the papers covered a wide field. Questioners were interested in methods of deoxygenation of water, in the design of absorption vessels and stirring mechanisms and in the performance of different types of aeration systems. Methods of measurement of dissolved oxygen concentrations were considered. Several speakers cited instances in which polarographic techniques had been used with success. The general opinion was that aeration studies could be of considerable value in improving practical fermentation processes, although rate of aeration was not always a factor limiting rate of production. Impedances in the organisms themselves were sometimes the controlling factor. In replying to questions arising out of his paper, Dr. Rolinson said that yeasts grown aerobically would probably not grow afterwards in complete absence of oxygen, although some growth might occur in partially anaerobic conditions. With regard to the Pasteur effect, this is not a permanent alteration of the enzyme system. He agreed that impedance across the cell wall cannot readily be distinguished from inability of enzyme systems to utilize oxygen when it became available.

TREND AND PATTERN OF FERTILITY IN GREAT BRITAIN

THE sixth, and final, volume of the Papers of the Royal Commission on Population describes the family census of 1946—its origins, methods and defects—and goes on to analyse in great detail the information collected. The joint authors are Prof. D. V. Glass, of the London School of Economics, and Prof. E. Grebenik, of the University of Leeds.

The family census was taken because some of the most important demographic questions with which the Royal Commission on Population was concerned

could not be answered in any other way. Since the normal census machinery could not be used, the family census was taken on a sample basis, the desired information being collected from a 10 per cent random sample of the women in Great Britain who were, or had been, married. It had no statutory sanction, but just over 87 per cent of the women responded—a very high response for a voluntary investigation. The extent of bias arising from non-response was examined, and it was found that any effect on the validity of the results could be safely discounted.

In part, the examination of the results follows the pattern customarily found in fertility censuses, in which the basic tables relate to the total number of children which the women had had by the time of the census. These tables show, for example, that of the women covered by the family census, 66 per cent had had not more than two children, and only 9 per cent had had six or more. On average, each woman had 2·3 live births by the time of the census: dividing the women into two broad social groups, manual and non-manual (based on the husband's occupation), the corresponding averages are 2·52 and 1·90 live births.

Study of the information by date of marriage shows clearly the decline in family size: for example, a woman married in 1920 had only about half as many children as a woman married before 1890—about 2·5 children in the former case, and about 5 in the latter. Whereas in the late nineteenth century families of five or more children constituted three-fifths of all families, the marriages of 1925 were dominated by one- and two-child families. Over this period, too, childlessness had doubled in frequency.

The statistics for all marriages (including childless marriages) show a consistent fall in family size with increasing age at marriage. But it is also shown that the relation between age at marriage and final family size is becoming somewhat less rigid. This is the kind of development which would be expected with the increasing acceptance of 'family planning' and with the spread of the small family.

A special feature of the family census was that the date of birth of each child was recorded. This information made possible the comparison of the families of different groups of marriages after different durations of marriage. For example, it was possible to compare the families, after six years of marriage, of women married in 1930 with the families, after six years of marriage, of those married in 1940. Such comparisons have enabled the authors to give a much clearer picture of current trends, and to make some tentative suggestions about the future.

The statistics show that the fall in family size has been accompanied not so much by a more widespread spacing between births, as by a contraction in the span of years during which children are born.

The general trend of ultimate family sizes, as deduced from the partial records available, shows a continued but slow fall in size of completed family for the marriages up to 1930, a fluctuating stability for the marriages of 1931–40, and thereafter a suggested increase in family size.

The data on family sizes have also been used for constructing replacement-rates indicating whether, with a continuance of fertility, marriage and mortality at certain specified levels, the population would ultimately increase or fall. For the women born in 1895–99, the estimated rate is only 0·74, well below the 1·0 which would show adequate long-term replacement of population. For more recent generations the replacement-rates will be higher; but the complete record of childbearing is not yet available. Marriage-rates have, however, been calculated and give a reasonably clear picture of the situation. Taking the marriages of 1941–43, the estimated rate ranges between 0·94 and 0·98, and this, although based in part on projected data because the families of these women are not completed, serves to suggest that the replacement-rates likely to result from recent marriages are not far from 1·0.

Far greater difficulties arise in attempting to predict the future of family size. Examination of the data suggests that family limitation is even more widespread in Britain than has been previously estimated, and that a further substantial fall in fertility is unlikely to occur simply through an extension of family planning. The analysis suggests that a new stability has developed in recent years, and that there may in fact have been some increase in family size since the Second World War. These developments have accompanied the spread throughout the community of the small-family pattern; nothing so far visible in the statistics foreshadows a major departure from that pattern in the near future.

NATIONAL RESEARCH DEVELOPMENT CORPORATION

REPORT FOR 1953–54

THE chief feature of the report and statement of accounts of the National Research Development Corporation for the year ended June 30, 1954*, is the quinquennial review of the Corporation's work, and this will be discussed separately. Among the new development projects in which the Corporation has interested itself during the year is a stereoscopic ciné camera, the development of which might be advantageous for educational, medical, scientific and technological purposes, and a technique for simplifying and economizing in the wiring of electric circuits.

Of projects already referred to in previous reports, the electronic digital computer continues to be the Corporation's largest single project, more than £325,000 of the £928,000 borrowed by the Corporation representing stocks, work in progress or patent expenditure in this field. Six big computers of the University of Manchester type have been ordered and have been or are being built for the Corporation's account, of which five have been sold and will have been delivered during 1954–55. The much less costly 401 Mark I computer has been transferred to Rothamsted Experimental Station after completing its trials at the Mathematical Laboratory, Cambridge, and is in routine use for calculations relating to agricultural statistics and other purposes. The design of a further computer embodying many of the successful devices in the prototype 401 has also been decided. The Packman potato harvester is now out of the development stage, and a number of machines are being made for the harvest this year. The Ricardo light steam-engine is now available for exploitation, and good progress has been made with the process of extracting hecogenin from sisal juice

* National Research Development Corporation. Report and Statement of Accounts for the Year 1st July, 1953, to 30th June, 1954. Pp. 20. (London: H.M.S.O., 1955.) 9d. net.

and purifying it to hecogenin acetate. Production and marketing of the chick sexer and aural microscope are proceeding satisfactorily.

Of the 664 inventions communicated to the Corporation during the year, 268 were from government departments and research councils, 50 from Commonwealth official organizations, 18 from industrial research associations, 38 from universities and 269 from British firms and individuals. The rights of 375 patents and patent applications were assigned to the Corporation during the year, of which 315 were from government departments and research councils, 14 from industrial research associations, 30 from universities and 8 from British firms and individuals. The Corporation now holds some 2,647 United Kingdom and overseas patents and patent applications, and, of the 272 licence agreements with industry in force, 99 were revenue-earning, producing £27,650 during the year.

CENTRAL LABORATORIES FOR SCIENTIFIC AND INDUSTRIAL RESEARCH, HYDERABAD

REPORT FOR 1953

THE annual report* for 1953 of the Central Laboratories for Scientific and Industrial Research, Hyderabad, stresses the increasing number of postgraduate students—twenty-two were working in the Laboratories for their Ph.D. in 1953—as evidence of the increasing contribution of the Laboratories both in training and in scientific and technical research. The research staff now numbers fifty-eight, and the report lists twenty-five papers published during the year, apart from forty communicated to the forty-first Indian Science Congress, held at Hyderabad in 1954.

In the Oils Section of the Laboratories, work was carried out on local bleaching earths, and on the preparation of dehydrated castor oil giving completely tack-free films and of alkyd resins modified by castor oil. The solubility and effectiveness of aca-catechin and katha-catechin as antioxidants in ghee were studied, the separation of fatty acid mixtures by adduct formation with urea was shown to be a much simpler method than conventional methods, and a suitable method was worked out for refining cotton-seed oil on a cottage-industry basis. The Entomology Section continued its studies of the toxicity of the seed oil from *Annona squamosa* (sitaphal) to vertebrates, and this oil appears to be fungistatic rather than fungicidal to *Helminthosporium* (paddy). The Paper Section was placed on a semi-commercial scale, and good progress was made in the manufacture of drawing paper and bond paper. In the Fuel Section the erection of the 12 ton/day ovoid briquetting plant was completed and the plant put into operation; experiments on binders for low-temperature tar continued. Further work was carried out on the distillation of low-temperature tar, the solvent extraction of tar acids and hydrocarbons from coal tar oils, and on benzole recovery from the low-temperature carbonization gas, while a systematic survey of the coalfields of Hyderabad commenced in July 1953.

The Heavy Chemicals and Fertilizers Section was occupied with the utilization of felspar (including studies of bricks from felspar sludge and on the influence of silica on the recovery of potash by the calcination process) and of iron pyrites (including the preparation of manganese dithionate, manganous sulphate and sulphur), the preparation of activated charcoal from teak-wood sawdust and from groundnut hulls, and the thermal decomposition of manganese sulphate and calcium sulphate to produce sulphur dioxide. The Ceramics Section made a systematic study of Hyderabad clays and the preparation of fireclay refractories from such clays. Investigations on potential synthetic analgesics in the Organic Chemistry, Pharmaceuticals and Drugs Section covered compounds of the quinazoline type and a new synthesis of pethidine. Studies on Indian turpentine included the preparation of a chlorinated product which was highly toxic to various insect tests, and work on the synthesis of menthol. In the work on compounds with œstrogenic activity, stilbene compounds were obtained by condensation of 3-chlorobutanone with phenol or its ethers in presence of sulphuric acid or anhydrous aluminium chloride, but the reaction is not general for α-halogeno ketones. The synthesis of 'Vanitrope' (2-ethoxy-5-propenylphenol) is being attempted and also the preparation of fine chemicals from fusel oil, while a series of ketones obtained by condensing lævulinic acid with aromatic aldehydes are being examined as plant growth regulators.

The Biochemistry Section has given its attention chiefly to the fermentation of pre-treated molasses to citric acid, to itaconic acid fermentation, to oxidations by *Pseudomonas fluorescens* and to the nitrogenous constituents of the seed cake of *Annona squamosa*. In the X-ray Section, X-ray studies were made of Hyderabad and Indian clays, while the Physical Chemistry Section investigated the conductivity of sulphuric acid in aqueous acetone and ethyl alcohol and the titration of tartaric acid with potassium dichromate. Besides the erection of the 25-ton/day low-temperature carbonization pilot plant, the Chemical Engineering Section completed work on the saturation solubilities of groundnut oil and cottonseed oil in aqueous ethyl alcohol and was further equipped with pilot-plant items for cotton-seed processing, vacuum distillation and the manufacture of synthetic resins.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, LONDON

REPORT FOR 1953–54

THE forty-seventh annual report of the governing body of the Imperial College of Science and Technology, London, covering the year ended July 31, 1954*, gives some details of the immediate proposals for expansion. Licences have already been granted for the erection of an additional story over the Goldsmiths' Company's extension to the City and Guilds College and the Royal School of Mines building, the first part of the extension of the chemical engineering building and the addition of two stories to the Union building. In January this

* Central Laboratories for Scientific and Industrial Research, Hyderabad. Annual Report, 1953. Pp. x+64. (Hyderabad—Deccan: Central Laboratories for Scientific and Industrial Research, 1954.)

* Imperial College of Science and Technology. Forty-seventh Annual Report of the Governing Body, 1953–1954. Pp. 65. (London: Imperial College of Science and Technology, 1955.)

year it was hoped to start the new joint building for aeronautics and for the further expansion of chemical engineering.

The academic plan envisages a much greater rate of increase in the engineering faculty than in the science faculty, with a postgraduate increase of about 160 per cent and an undergraduate increase of about 44 per cent. It is hoped to provide eventually for about fifteen hundred undergraduate and fifteen hundred postgraduate students, with perhaps half of the latter engaged in research. With the aid of a modest increase in the recurrent grant for 1954–55 and the income from the American Counterpart Funds, it is hoped that the University of London will be able in the near future to appoint professors of applied science with special reference to engineering, soil mechanics, statistics, applied geophysics and heavy electrical engineering. The new chair in heavy electrical engineering and the new readership in production engineering have been financed from sums available under the government programme for the expenditure of the Counterpart Funds, and it is expected that investment of the capital sum involved will make available about £8,000 a year. The Cement Manufacturers' Association has covenanted for a second ten years to pay £2,000 a year to continue the chair of concrete technology, and some twenty-two companies are now contributing £200 a year each to the Building and Civil Engineering Contractors' Bursary Fund. A number of seven-year covenants which will produce £2,300 a year have also given a new lease of life to the Nuffield Research Group in Extraction Metallurgy, apart from the permanent income of £500 a year eventually assured from the Imperial Smelting Corporation's Fund and the further £15,000 over five years provided by the Nuffield Foundation.

The number of full-time students for the year under review was 1,727, compared with 1,653 in 1952–53, and, of these, postgraduate students in science and in technology numbered 223 and 349, respectively, compared with 225 and 314 in 1952–53. Of the full-time students, 111 were from foreign countries, 213 from Commonwealth countries outside the British Isles and 591 from the British Isles outside a radius of thirty miles from the College. Besides details of staff changes and the statement of accounts, a list of publications in 1953–54, arranged departmentally, is appended to the report.

A SIMPLE METHOD FOR STUDYING AND DEMONSTRATING THE ENERGY CONSUMPTION IN FLYING INSECTS

By Dr. OLAVI SOTAVALTA

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RELATIVELY little information exists about the energy consumption in insects; what is available consists of observations on some single species of Hymenoptera, Diptera and Orthoptera only. Beutler[1] gives data on sugar consumption in the honeybee, recorded on specimens in free flight in a *Flugaquarium* of glass. Wigglesworth[2] obtained energy consumption data of *Drosophila* by waxing the specimen to the head of an insect pin stuck in the cork of a glass vial, and stimulating it to flight by suddenly withdrawing the cork. More or less elaborate flight-mills for studying various aspects of flight of insects, including energy consumption, have been built by several authors[3].

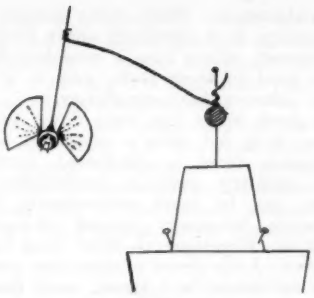

Fig. 1

I have devised a method which was used for energy consumption studies on the honeybee, *Drosophila* and some other Diptera at Tufts College, Medford, Massachusetts, during 1952–53[4]. It is a simplified flight-mill or 'roundabout' which consists of a metal wire of suitable length, rigidity and thickness, wound loosely by one end around an insect pin, so that it can rotate easily. The pin is passed through a small ball of moulding clay to prevent the wire from falling down, and is stuck in a piece of cork (Fig. 1). The other end of the wire is wound tightly around another insect pin head down, at its point end, and the insect is, under carbon dioxide or ether anæsthesia, waxed at its thorax under a binocular microscope to the head end of the pin. The position of the insect in respect to the three axes of space is adjusted by bending the wire and by rotating the pin within the 'tight' wire coil. In order to obtain an effective flight, the insect has to face the direction of the movement, with the long axis of the body horizontal. If the body is vertical the movement may take place backwards.

Insects mounted to the instrument usually start flying when the support (a piece of paper, or a cotton ball) is removed from under the tarsi. If the insect refuses to start flying or stops by itself during flight, flight can be initiated easily by rotating the instrument backwards. As soon as a tarsus touches an object, which may be a deliberately offered support or a part of the insect's own body, the insect stops flying.

The quality of the wire and pin has naturally to conform to the size and powers of the insect. Instead of waxing to the head of a pin, small insects can be conveniently glued to the uncoiled free end of the wire with a drop of 'Duco', 'Durofix' or other suitable cement, considerably thinned with acetone.

This instrument is almost frictionless and easily rotated by the insect. Few insects except *Drosophila* are willing to fly stationary attached to an immovable pin according to the method of Wigglesworth[2]; but a considerable number fly well in this kind of roundabout. Honeybees and several other Hymenoptera are good subjects for experimenting, and flies that normally fly quietly, without sudden changes of speed, can also be used. The lesser housefly (*Fannia canicularis*) is an ideal subject, while the common housefly (*Musca domestica*) and many larger flies are less satisfactory, since they generally fly in bursts and have to be stimulated to flight incessantly. Once the flight has started, it can go on for hours until the

insect is exhausted. While many insects consume all their energy in a relatively short time and are easy to exhaust, others have a considerable amount of reserve food in their body, and it is therefore difficult to exhaust them completely.

After a fresh insect has been flown to complete exhaustion, it is fed with a measured amount of sugar solution from a graduated micro-pipette. Standard capillary pipettes graduated in cubic millimetres can be used conveniently for larger insects, while internally waxed and calibrated pipettes of the Wigglesworth type[5] must be used for small insects. After a rest of some few minutes, the flight can be started and timed, until the insect is again completely exhausted.

The insects generally maintain a remarkable speed in the roundabout, and seven to eight revolutions per second is nothing unusual. However, since the rigid wire supports the weight of the insect, all the work output is used for propulsion, and the speed observed in the roundabout therefore must not be equated with the speed of free flight of the species to be examined. [Nov. 14

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RESISTIVITY IN METALS

Resistivity Changes by Plastic Deformation of Polycrystalline Metals

ANNEALED polycrystalline wires of 99·9 per cent purity copper and of 99·99 per cent purity silver, 93 mm. long and 0·5 mm. in diameter, have been plastically deformed in extension and in torsion at 20° K. and at 77° K., and their resistivity has been measured. The apparatus used is depicted in Fig. 1. Tension is applied to the specimen F immersed in liquid hydrogen or nitrogen through the spring B by moving the rod A upwards at a constant rate by means of a small motor. Elongation of the specimen is indicated by the pointer C; the force is deduced from the elongation of the spring, indicated by the pointer D. The wire can be twisted by means of the torsion head E; one complete turn corresponds to a shear strain of 0·017 at the surface. The potential leads were soft-soldered to the specimen; resistivity was determined with a Diesselhorst potentiometer.

First the wires were extended (to about 10 per cent), then a twist was applied (corresponding to a surface strain $\varepsilon_t \approx 0{\cdot}1$), and afterwards the wires were extended further. In some cases a twist with subsequent extension was applied for a second time. The relative variation of resistivity at the temperature of deformation as measured on several specimens has been plotted in Fig. 2. Analysis of the curves yielded the following results.

The extra resistivity depends on extension $\Delta l/l$ according to a power law:

$$\Delta\rho_e = a(\Delta l/l)^p \qquad (1)$$

The exponent p differs from sample to sample. In most samples p lies between 1·2 and 1·4; once (copper at 77° K.) p was found to be 1·7. The constant a amounts to about 0·06 $\mu\Omega$ cm., with a

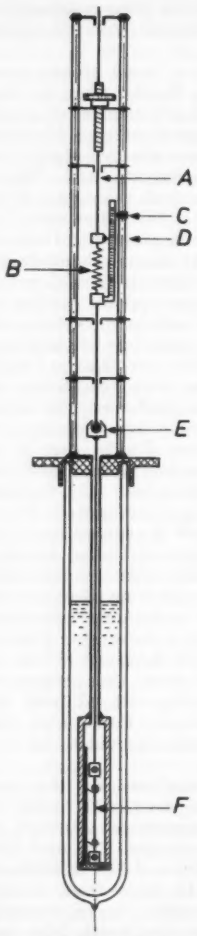

Fig. 1. Schematic drawing of low-temperature deformation device

scatter of the order of 20 per cent, regardless of material or temperature. Experiments by Druyvesteyn and Manintveld[1] on wires of copper, silver and gold at 77° K. have yielded approximately the same results. According to their observations $p = 1{\cdot}5$ in all cases; a was comparable to our values[2].

The resistivity increase on twisting is roughly proportional to the applied twist—it is about 0·04 $\mu\Omega$ cm. at $\varepsilon_t = 0{\cdot}1$; again, no definite dependence on material or temperature could be detected. Reverse twisting has, apart from the first two or three per cent in ε_t, the same effect as direct twisting.

On subsequent extension again a power law of the form (1) is obtained, except for the first few per cent of strain. The exponent p has remained remarkably constant; only the coefficient a has become greater by a 'multiplication' factor m which increases with the twist, and is about 1·3 for $\varepsilon_t = 0{\cdot}1$, regardless of material or temperature.

The extra resistivity of a plastically deformed metal must be attributed to dislocations or to point defects (vacancies and interstitials) or to both. Assuming the dislocations to be formed by Frank-Read sources and the point defects by the effect of intersection of dislocation loops with dislocations already present in the material, the existence of a power law with exponent slightly greater than 1 can be shown to be in good agreement with the idea that point defects contribute to most of the resistivity rather than dislocations[2,3]. The dislocation density in the material after 10 per cent extension being certainly not higher than 10^{11} cm.$^{-2}$, their influence on the resistivity should, according to calculations by Hunter and Nabarro[4], be less than $10^{11} \times 0{\cdot}4 \times 10^{-14}$ $\mu\Omega$ cm. $= 4 \times 10^{-4}$ $\mu\Omega$ cm. in copper, while 3×10^{-3} $\mu\Omega$ cm. was observed. The density of point defects formed, taking d_0, the density of dislocations originally present, to be 10^8 cm.$^{-2}$, is found, after 10 per cent extension, to be about 10^{18} cm.$^{-3}$. The resistivity increase by vacancies in copper was computed by Jongenburger[5] as 1·3 $\mu\Omega$ cm./per cent vacancies; that caused by interstitials is probably somewhat larger (see following communication), namely, 5 $\mu\Omega$ cm./per cent interstitials. Taking 3 $\mu\Omega$ cm./per cent defects as a mean value, the concentration mentioned of defects

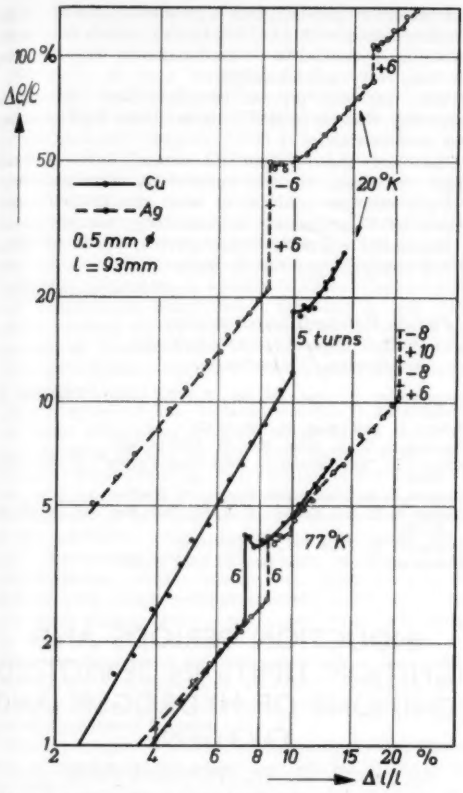

Fig. 2. Relative increase of resistivity $\Delta\rho/\rho$ as a function of extension $\Delta l/l$ and of twist (expressed in the number of complete turns of the torsion head) for copper (full curves) and silver (dashed curves) wires. A minus sign of the twist refers to reverse twisting

accounts for 0·003 μΩ cm. of the extra resistivity, which is in agreement with the observation.

The results of the combined twisting and extension experiments seem to confirm these conclusions. A surface strain of 0·1 of the wire corresponds to the introduction of $1{\cdot}3 \times 10^8$ new dislocations per cm.[2]. Their influence on the resistivity is, according to Hunter and Nabarro, only $0{\cdot}5 \times 10^{-6}$ μΩ cm., as compared to the observed increase of 0·004 μΩ cm. By the process of intersecting dislocations, point defects are also formed. From the dimensions of the specimen and the applied twist, it is found that the number of defects formed is 5×10^{17} cm.$^{-3}$ at $\varepsilon = 0{\cdot}1$; this results in an increase of resistivity of 0·002 μΩ cm., which is in much better agreement with observations.

The occurrence of the multiplication factor m, rather than an additive effect on resistivity alone which remains constant on further extension, also points to the effect of point defects on resistivity as being by far the most important one. The introduction of new dislocations, homogeneously distributed and of predominantly screw character, increases the rate at which expanding loops around Frank–Read sources form point defects in the ratio new density of crossing dislocations to old density d_0 (before the twist). However, the action of the sources is slightly impeded by the increase in dislocation density, and it can be shown[3] that one can put approximately $m = (d/d_0)^{3/4}$. From the observed value of m and the known number of newly introduced dislocations, d_0 can be computed. It is found that $d_0 = 3 \times 10^6$ cm.$^{-2}$, a reasonable value in view of the uncertainties of the theory.

The conclusion that point defects can be held responsible for nearly all the resistivity increase caused by plastic deformation of polycrystalline metals, and that the direct effect of dislocations plays only a minor part in this respect, seems, from the results of the experiments, to be warranted.

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Extra-Resistivity due to Interstitial Atoms in Copper

Some time ago we performed calculations on the extra-resistivity due to vacancies in copper, silver and gold[1]. When we tried to extend our calculations to the case of interstitials, this turned out to be much more complicated. Therefore, only a very rough estimation will be presented here, concerning copper.

Theoretical arguments can be raised against the method used; but it finds some justification in the fact that it gives results of the correct order of magnitude in some cases, as will be shown below.

Scattering of the conduction-electrons is caused by: (*a*) the interstitial atom itself, and (*b*) the displacements of the neighbouring atoms. The extra-resistivities due to these causes are supposed to be additive. The free-electron approximation is used.

(*a*) We represent the interstitial atom by a rectangular attractive field with radius a and depth U_0. As in the case of vacancies, we adjust U_0 in such a way that the asymptotic phase shifts α_l obey Friedel's[2] equation $\sum_l (2l+1)\alpha_l = \pi/2$. Unfortunately, when performing this calculation for a number of a's, it turns out that the scattering area A varies much more with a than in the case of vacancies (Fig. 1). Taking a equal to r_s we find, but with a much greater uncertainty than in the case of vacancies, $\rho_a \sim 1 - 2$ μΩ cm./per cent interstitials. In passing, we remark that the use of an effective electron mass m^* instead of the free electron mass m gives essentially the same result if U_0 is again adjusted in the way indicated.

(*b*) The displacements of the neighbouring atoms were calculated by Huntington[3]. In his configuration B we have 6 atoms with a displacement of 0·40 A. and 24 atoms with a displacement of 0·13 A. From this we find the mean of the square of the x-component of displacement for 1 per cent of interstitials in the following way:

$$\overline{\delta^2_x} = \frac{1}{3}\,\frac{6 \times (0{\cdot}40)^2 + 24 \times (0{\cdot}13)^2}{100} = 0{\cdot}0046 \text{ A}^2.$$

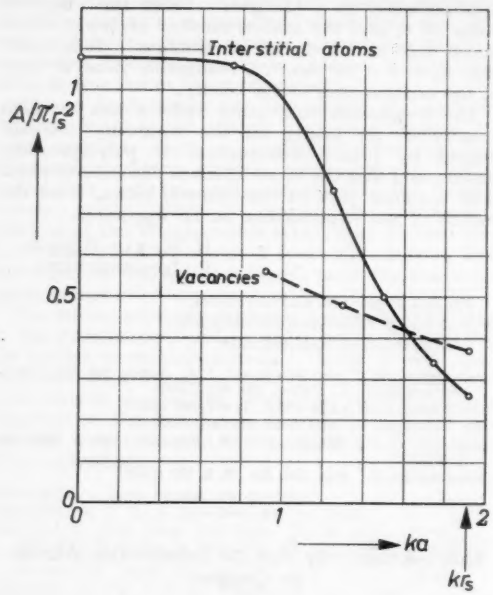

Fig. 1

The displacement of the copper atoms due to thermal motion at room-temperature is given by: $\overline{\delta^2_{Tx}} = 0{\cdot}0022$ A². So the extra-resistivity due to the displacement of neighbours is estimated to be:

$$\rho_d = \frac{0{\cdot}0046}{0{\cdot}0022}\,1{\cdot}67 = 3{\cdot}5\,\mu\Omega\text{ cm./per cent interstitials}$$

Of course, this estimation is very crude, as the displacements due to the presence of an interstitial atom are not correlated with each other in the same way as the displacements due to thermal motion. But as the thermal resistivity itself can be estimated rather well without taking into account any correlation between the positions of the atoms[4], also in this case the order of magnitude will probably be correct. Moreover, the method works rather well in the case of a solid solution of carbon in iron. As is well known, this is an interstitial solution, the carbon atom being placed in the middle of the edges of the body-centred cubic cell. We assume that only the two nearest iron atoms are displaced, and that the extra-resistivity is only (or mainly) caused by these displacements, the carbon atom being neutral. Then from the observed extra-resistivity[5], following the method presented before, we find that the two nearest iron atoms are displaced 0·4 A. each. This is a reasonable value, the radius of the available site being 0·2 A. and of a carbon atom 0·8 A.

The extra-resistivity due to edge-dislocations can also be estimated on these lines; we find about the same value as Hunter and Nabarro[6].

We conclude, therefore, that also in our case we have made a reasonable estimation of the extra-resistivity due to the displacements; our result, however, is in striking disagreement with the calculations of Dexter[7], who concludes that the contribution of the displacements to the resistivity can be neglected. The cause of this discrepancy is not understood at present, but is probably caused by the transformation of his eq. (9) to (9′), which causes the scattering potential to be smeared out, thus lowering the resistivity considerably.

From (*a*) and (*b*) we conclude that the extra-resistivity due to interstitials is about 5 $\mu\Omega$ cm./per cent interstitials.

The fact that interstitial atoms have a much larger influence on the resistivity than vacancies (1·3 $\mu\Omega$ cm./per cent) is at least qualitatively confirmed by Overhauser's stored-energy measurements in irradiated copper[8], which gave a value of about 10 $\mu\Omega$ cm./per cent interstitials.

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INDUCTION PERIODS AND IGNITION LIMITS IN SENSITIZED IGNITIONS OF HYDROGEN AND OXYGEN

By Prof. R. G. W. Norrish, F.R.S., and Dr. P. G. Ashmore

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and

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The work of Hinshelwood and Thompson[1] upon the effect of nitrogen dioxide on the thermal reaction between hydrogen and oxygen was extended by Griffiths and Norrish[2] and by Foord and Norrish[3]. The success of Semenoff's treatment[4] of branched-chain reactions led Foord and Norrish to assume that the sensitized reaction is a simple branched-chain reaction and that the induction period (τ) is the time for the concentration of the chain centres (n) to reach a critical value (n_c). Hence, provided the net branching factor (φ) and the rate of initiation (θ) do not vary during the induction period, the expression for the latter is:

$$\tau = \frac{1}{\varphi}\ln\left(1 + \frac{\varphi}{\theta}n_c\right) \qquad \text{(i)}$$

Also, it was frequently assumed that θ and φ are so related that variations in the logarithmic term are small, and τ was therefore regarded as being approximately inversely proportional to φ. This relation between τ and φ was used to make deductions about the properties of φ from the observed dependence of τ on certain experimental variables, and, when combined with the notion that explosion occurs when φ exceeds a critical value (φ_c) determined by the thermal capacity and the conductivity of the system,

formed the basis of a reasonably satisfactory explanation of the main features of the sensitized ignitions with nitrogen dioxide[3,5] and with nitrosyl chloride[5].

However, it was recognized that two results frequently obtained by different observers[5,6] are at variance with this theory. With constant pressures of hydrogen and oxygen, when φ_e is constant, it was found that (1) the value of τ at the higher sensitizer limit of ignition often exceeds the value at the lower limit, and (2) at low sensitizer concentrations τ frequently increases as the sensitizer concentration is increased and the system passes from a region of slow reaction to one of ignition. If the relation $\tau\varphi$ equal to a constant is applied to these observations, then it must be concluded: (1) that φ can have different values at the two limits, and (2) that φ can decrease in passing from slow reaction to ignition. The unsatisfactory nature of these conclusions needs no emphasis.

The purpose of this communication is to indicate how these difficulties may be resolved by regarding the induction period as the time during which φ is progressively increasing, while retaining the condition that, if φ exceeds a critical value, explosion results. The increase is brought about by the decomposition of the additive, which functions principally as a chain terminator, to yield nitric oxide; as the decomposition occurs partly by reaction of the additive with chain centres, and the nitric oxide can start fresh chains, there is a delayed chain branching. The view that "nitric oxide is the true catalyst . . . whilst nitrogen peroxide is an inhibitor . . ." was first adopted by Griffiths and Norrish[2]. Because φ is changing during the induction period, equation (i) is now considered invalid.

The experimental evidence (Ashmore, *Trans. Farad. Soc.*, in the press) for this view will be briefly summarized.

(i) In the same vessel at any particular temperature, the lower and upper limits of sensitizer for ignition are the same whether the original additive is nitrosyl chloride, chloropicrin, nitrogen dioxide, or a mixture of nitrogen dioxide and nitric oxide.

(ii) On the other hand, the induction periods are shorter the more readily the original additive decomposes. For equimolar amounts of additive, the induction period with chloropicrin is less than that with nitrosyl chloride, which in turn is less than that with nitrogen dioxide.

(iii) When the additive is placed in the reaction vessel before the reactants (rapid mixing being ensured; see Ashmore and Chanmugam[7]) the induction periods are shorter the longer the additive has been in the vessel, and they can become zero.

(iv) If nitric oxide is introduced first into the reaction vessel, and the reactants added, instantaneous ignitions occur if the nitric oxide concentration is above a value which diminishes as the concentrations of the reactants are increased; however, there is no upper limit. If a little nitrosyl chloride or nitrogen dioxide is mixed with the reactants, the upper limit reappears.

(v) When reactants containing nitrogen dioxide are added to a reaction vessel containing nitric oxide, keeping the total number of moles, nitric oxide + nitrogen dioxide, constant, there is a marked and regular decrease in the induction periods as the proportion of nitric oxide in the reaction vessel is increased. This occurs throughout the ignition region and just above the upper limit.

(vi) There is now clear evidence from photometric work in progress at Cambridge that nitrogen dioxide disappears during the induction period for mixtures of hydrogen, oxygen and nitrogen dioxide admitted in the normal manner. The concentration of nitrogen dioxide just before ignition is smaller the larger the initial concentration of nitrogen dioxide. Near the upper limit, less than 5 per cent usually remains.

A kinetic scheme has been developed which includes the following reactions in addition to those believed to occur in the unsensitized hydrogen–oxygen reaction and in the molecular decompositions of chloropicrin, nitrosyl chloride, and nitrogen dioxide:

$$H + NO_2 \rightarrow NO + OH \quad (1)$$

$$NO + O_2 \rightarrow NO_2 + O \quad (2)$$

$$O + NO_2 \rightarrow NO + O_2 \quad (3)$$

$$OH + NO_2 + M \rightarrow HNO_3 + M \quad (4)$$

$$H + NOCl \rightarrow NO + HCl \quad (4a)$$

$$HO_2 + NO \rightarrow NO_2 + OH \quad (5)$$

Hydrogen atoms from the main chain reduce nitrogen dioxide to nitric oxide by reaction (1), and in so doing produce the main-chain carrier OH. The main chain is thus continued. In addition, the nitric oxide generates an oxygen atom in reaction (2); and when this atom is not destroyed but reacts with molecular hydrogen, additional chains are started and therefore the rate of chain branching has been augmented. Nitric oxide also increases φ by converting HO_2 radicals (which at the temperature concerned are not chain carriers but probably diffuse to, and are destroyed at, the wall) into hydroxyl radicals. The additives themselves are chain terminators by virtue of reactions such as (4) and (4*a*). It is interesting to note that in all the reactions mentioned the integrity of the NO group is preserved. The remarkable effects of nitrogen dioxide and of nitrosyl chloride are due to the high dissociation energy of N—O and the relatively low dissociation energies of ON—O and ON—Cl.

An expression for the net branching factor φ has been derived, and its variation with concentration of nitric oxide and nitrogen dioxide studied. If the condition for ignition is assumed to be that, whatever temporal changes φ undergoes during the induction period it does not attain the critical value φ_e (which may be zero or positive) until the end of the induction period, then the predicted changes in the induction periods and in the ignition limits are in very satisfactory qualitative agreement with those found experimentally for appropriate conditions of reactant pressure, pressure of additive, inert gas pressure and irradiation. It seems likely that some quantitative relationships will follow from the photometric studies now in progress. In the meantime, the evidence for the destruction of the additive as the cause of the induction period and for the absence of any simple connexion between φ and τ in these sensitized ignitions seems very strong. [Jan. 22

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LETTERS TO THE EDITORS

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Cephalosporin C, a New Antibiotic containing Sulphur and D-α-Aminoadipic Acid

A SPECIES of *Cephalosporium* produces a hydrophilic penicillin, called cephalosporin *N*, which yields D-α-aminoadipic acid on hydrolysis[1]. Crude preparations of cephalosporin *N* have been found to show strong absorption in ultra-violet light at 260 mμ, although highly purified cephalosporin *N* shows very little absorption at this wave-length. A new antibiotic with an absorption maximum at 260 mμ has now been isolated from the crude preparations in the form of a crystalline sodium salt. It resembles cephalosporin *N* in certain physical, chemical and biological properties, but differs from it sharply in others.

Cephalosporin *C* sodium salt ($[\alpha]_D^{20}$ + 103° ; $\lambda_{max.}$ 260 mμ, $\varepsilon_{max.}$ 9,500) separates from aqueous ethanol or aqueous propanol in monoclinic crystals. Its equivalent weight, determined by titration, is 480 ± 15. X-ray crystallographic measurements were kindly made by Dr. Dorothy Hodgkin and Mrs. M. Mackay, who reported as follows : unit cell dimensions : $a = 13{\cdot}12$ A. ; $b = 4{\cdot}97$ A. ; $c = 17{\cdot}82$ A. ; $\beta = 106°\ 30'$. Space group, $P2_1$; number of molecules in the unit cell, 2 ; density, 1·38. The molecular weight, calculated from these figures, is 470 ± 15.

On drying *in vacuo* at room temperature, cephalosporin *C* sodium salt loses two moles of water which are rapidly regained on exposure to laboratory air. The results of elementary analysis, together with the value for the molecular weight, indicate that a possible molecular formula for the crystalline hydrate is $C_{16}H_{26}O_8N_3SNa,2H_2O$; but this formula is only a provisional one and may need revision.

The infra-red spectrum of cephalosporin *C* sodium salt (in paraffin paste) shows bands at the following wave-lengths : 2·94μ, 3·06μ, 5·61μ, 5·77μ, 6·05μ, 6·29μ, 6·57μ, 7·17μ and 7·36μ. It is of interest that a band in the region of 5·61μ is shown by the common penicillins and by cephalosporin *N*, and has been attributed in the former to the C=O of the fused β-lactam-thiazolidine ring system[2]. The band at 5·77μ could be due to an ester or lactone grouping.

Cephalosporin *C* gives a ninhydrin reaction. Electrometric titration indicates that it is a monoaminodicarboxylic acid, having two acidic groups with *pK* values of 3·1 and <2·6 respectively and a basic group with a *pK* value of 9·8. When subjected to ionophoresis on paper in a collidine–acetate buffer at *p*H 7, it migrates towards the anode at almost the same rate as cephalosporin *N*.

Unlike cephalosporin *N* and benzylpenicillin, cephalosporin *C* is stable in aqueous solution at *p*H 2·5 at room temperature. It is rapidly inactivated, however, with loss of its characteristic absorption spectrum, at *p*H 12. After it has been kept in aqueous solution at *p*H 12 for two hours, back titration shows that two acidic groups per mole have been formed. Under similar conditions only one acidic group is liberated from cephalosporin *N* and benzylpenicillin.

Cephalosporin *C* is not inactivated by penicillinase from *B. subtilis*, strain 569[3]. It loses activity, though much less rapidly than cephalosporin *N* or benzylpenicillin, in the presence of a crude preparation of penicillinase from *B. cereus* (*NRRL* 569). The inactivation is accompanied by the liberation of an acidic group and loss of absorption at 260 mμ. It appears to be caused by an enzyme other than penicillinase which is present in the preparation. The ratio (cephalosporinase activity/penicillinase activity) was much lower with highly purified penicillinase[4] from *B. cereus* than with the crude material.

On hydrolysis with acid, cephalosporin *C*, like cephalosporin *N*, yields one mole of carbon dioxide and D-α-aminoadipic acid. The product obtained by allowing cephalosporin *C* to react with 1 : 2 : 4-fluorodinitrobenzene yields, on hydrolysis, a substance which behaves like dinitrophenyl-α-aminoadipic acid on paper chromatograms. It therefore appears that cephalosporin *C* contains a residue of D-α-aminoadipic acid and that the α-amino group is free. The *pK* value of this group suggests that the α-carboxyl group is also free.

Hydrolysis of cephalosporin *C* with acid yields little, if any, penicillamine. However, the carbon skeleton of penicillamine appears to be present in the molecule. Hydrolysis of the product obtained from cephalosporin *C* by hydrogenolysis with Raney nickel yields, in addition to α-aminoadipic acid, an amino-acid which behaves like valine on paper chromatograms.

Cephalosporin *C* is less active than cephalosporin *N* against most of the bacteria tested, although the two compounds show similar activities against a strain of *Bact. coli*. Against *Staph. aureus* and *Salm. typhi*, cephalosporin *C* shows an activity[5] of 8–10 units per mgm.

In 1951 a strain of *Cephalosporium* isolated in the United States was reported to produce an antibiotic called synnematin[6]. Abraham, Newton, Crawford, Burton and Hale[7] directed attention to the possibility that synnematin was identical with cephalosporin *N*. Synnematin was later separated into two components called synnematin *A* and synnematin *B*, the former being apparently less soluble in methanol than the latter[8]. The behaviour of crude synnematin *B* on paper chromatograms buffered with sodium citrate, *p*H 5·5, and run with methanol[8] appears to be very similar to that of cephalosporin *N* ($R_F = 0{\cdot}44$). However, the reported behaviour of crude synnematin *A* under these conditions ($R_F = 0$) is different from that of cephalosporin *C* ($R_F = 0{\cdot}34$).

We are grateful to the Distillers Company (Biochemicals), Ltd., and to Dr. M. R. Pollock for gifts of penicillinase.

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An Infectious Nucleoprotein from Tobacco Mosaic Virus

We have reported previously the degradation of tobacco mosaic virus in alkaline solution into a series of sub-units, of which the molecular weights could be determined in the ultracentrifuge. By reaggregation of these sub-units, we obtained a protein that had the same size and shape as the virus itself, but was not infectious[1]. Recently the process of degradation has been studied exhaustively by fractionating the products by electrophoresis. We carried out many experiments, varying the *p*H, the time of degradation and the temperature. We mention here only one typical pattern obtained three hours after adjusting the *p*H to 10·3 at 0° C., which is reproduced in Fig. 1; it shows five different boundaries, of which Nu has the highest and IV the lowest mobility. Each fraction was isolated for study; the results are listed in Table 1.

Table 1. Electrophoretical Fractions of Tobacco Mosaic Virus. 3 hr., *p*H 10·3, 0° C.

Fractions	Nu	I	II	III	IV	TMV
Mobility, ascending	−15·6	−12·7	−10·2	−9·2	−5·5	−9·2
Ribonucleic acid (per cent)	90	15	9	6	0	6
s_{20} in *S*, c=0·4 per cent	4·2	80–160		80–180	4·6	180
Infectivity	—	—	+	+	—	+

Fraction I contains 90 per cent ribonucleic acid and 10 per cent protein. The sedimentation constant indicates a high molecular weight. Electronmicrographs show that the ribonucleic acid has a filamentous shape (Fig. 3). Fractions I and II contain more ribonucleic acid than the original virus. In the ultracentrifuge we found several definite components, which had smaller sedimentation constants than the original virus. Fraction III is identical with the original virus with regard to ribonucleic acid content, mobility and sedimentation constant, but in the ultracentrifuge a small amount of material of lower molecular weight was also observed. Fraction IV is a protein free of ribonucleic acid with a molecular weight of about 100,000. It is identical in all its properties with a natural by-product of virus reproduction that we isolated from virus-infected tobacco plants by the method of Takahashi[2]; in particular, we obtained the same intermediates and final products in the reaggregation.

After prolonged exposure to *p*H 10·3, the nucleoproteins I and II were converted into ribonucleic acid and protein (IV). Fractions I and II may therefore be termed the 'labile fraction'. Surprisingly, fraction III does not disintegrate to protein and ribonucleic acid even after months at *p*H 10·5. It is therefore termed the 'stable fraction'. In different preparations of normal tobacco mosaic virus we always found the same proportion (30 per cent) of the stable fraction; but in a preparation of the Dahlemense strain the amount was significantly lower (12 per cent).

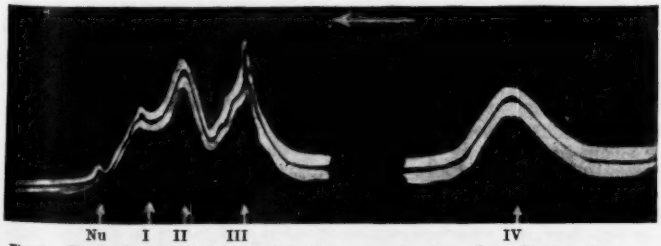

Fig. 1. Electrophoresis of disintegrated tobacco mosaic virus, descending boundary

Fig. 2. Tobacco mosaic virus particles with gaps from fractions I+II. × 150,000

In the initial phase of the degradation the labile fraction and the stable fraction are both highly infectious in the local-lesion test with *Nicotiana glutinosa* and *Phaseolus*, whereas Nu and fraction IV are not infectious. After prolonged treatment, all components become inactive. By centrifugation of fractions I+II at 25,000 r./min. a fraction of high molecular weight was separated which had nearly the same infectivity per mgm. protein-nitrogen as the original virus. Since the ribonucleic acid content, the sedimentation constant, and the mobility show that this material is quite distinct from tobacco mosaic virus, we probably have for the first time a biologically active degradation product of the virus.

At the very beginning of the degradation protein appeared, but no ribonucleic acid. It is therefore probable that fractions I+II are formed from the tobacco mosaic virus by loss of protein, so that the ribonucleic acid content is higher than that of tobacco mosaic virus, a conclusion that is confirmed by the electronmicrograph. In fractions I+II we observed rods of tobacco mosaic virus with gaps, where only a thin filament, probably of ribonucleic acid, is to be seen (Fig. 2). Filaments of the same diameter can be seen on Fig. 3, where some rods are totally disintegrated to ribonucleic acid and disks of protein having the same diameter as the rods, a thickness of about 70 A., and a hole in the centre. We suggest that in the virus these disks are strung on a thread of ribonucleic acid. From the electronmicrographs we estimate the diameter of the filaments to be 30–40 A. at the most. If all the ribonucleic acid were concentrated in one strand of the same length as tobacco mosaic virus, the diameter would also be 30 A. The increased mobility of fractions I+II may be caused by the loss of protein, though other explanations are possible; but it cannot be due to the adsorption of ribonucleic acid on the intact virus particles, as we have been able to

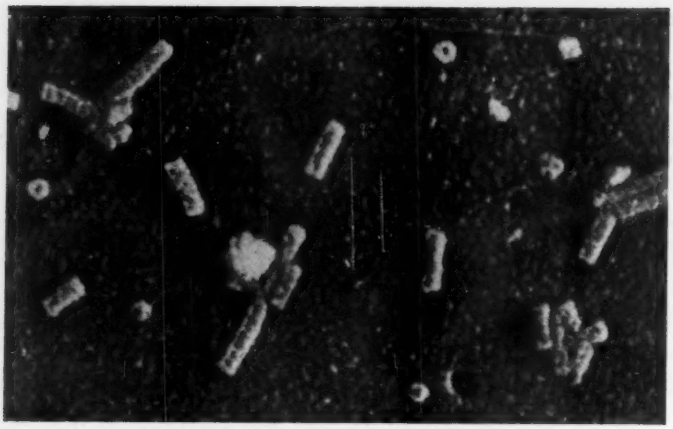

Fig. 3. Fragments of tobacco mosaic virus, filaments of ribonucleic acid and protein disks with a hole. × 150,000

prove by electrophoresis of a mixture of ribonucleic acid and tobacco mosaic virus.

A more detailed report of this work will be published in the *Zeitschrift für Naturforschung*.

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Cellular Control in Virus Infection

Marked changes may be produced by virus infection in a host cell when the amount of virus material is very small compared with the amount of host cell and when some of the host's synthetic activities are altered by the presence of the virus. Many authors refer to this control of the cell by the infecting particle; but experimental evidence is very scanty. In infection by coliphage T_2, Cohen[1] has shown that infected cells use an alternative metabolic pathway to a greater extent than do normal cells. No definite information is available in mammalian virus infections as to the presence of such metabolic alterations, nor the means by which such changes could be produced.

In mouse liver infected with ectromelia virus at initial infecting levels of about 1 *LD* 50 per liver cell, the infectious titre drops to less than 1 per cent of the initial level and then returns to the initial titre at about 11 hr. The titre remains stationary until about 22 hr., when an increase of some thirty-fold occurs. It was suggested recently[2] that the eclipse period was concerned with establishing control of the cell before multiplication occurred. Evidence which supports this suggestion has been obtained by studying the effect of this virus on regenerating liver. It was found that at the same stage of regeneration there was a lower mitosis-rate in livers of mice infected 12 hr. previously than in livers of uninfected mice. For example, in young mice examined 40 hr. after partial hepatectomy, an uninfected group had a mitosis-rate of $6{\cdot}7 \pm 0{\cdot}6$, whereas a group infected for 12 hr. had an average mitosis-rate of $1{\cdot}4 \pm 0{\cdot}3$. Mice infected for longer periods show a more marked effect, mitosis being rare after 20 hr. of infection. In the first 12 hr. of infection, we have been unable to detect any abnormality in morphology or composition of liver, or any alteration in oxygen uptake, fructose utilization, or lactic acid production. The infectivity titre shows no virus multiplication at this time, and stays unaltered until about 22 hr. Complement-fixing antigen rises to detectable level at 12–14 hr. and increases in roughly linear fashion. Results of preliminary experiments show that the deoxyribonucleic acid per nucleus is the same in infected and non-infected cells at the same period of regeneration.

The control of mitosis appears at an early stage of infection, and is established at the end of the eclipse period, which appears to be the onset of time of multiplication of virus material. The time sequence suggests that the effect on mitosis may be closely related to the essential primary effect of the virus on the cell. The lack of other changes found in the liver after 12 hr. of infection makes the phenomenon less likely to be a secondary change, though they provide no lead as to the biochemical basis.

A further indication of disturbance of normal control is found later in the growth-cycle. In intact livers studied 30–40 hr. after infection, there is an increase in the amount of cytoplasmic material far greater than can be accounted for by virus. There is an increase in the ratio of cytoplasmic to nuclear volume and in the amount of protein per liver, without any increase in the amount of deoxyribonucleic acid. There is no increase in the number of cells.

As a working hypothesis, we consider that the alteration in cellular economy necessary for virus production, first indicated by control of mitosis, leads to the production of more cytoplasm, and this abnormal form of growth is followed by damage to the cell. Cellular damage is regarded, however, as a by-product of, rather than a prerequisite for, virus multiplication.

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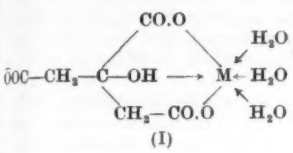
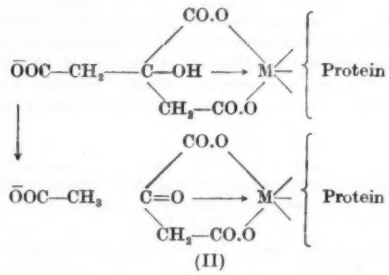
A Mechanism for Citrate Dissimilation

Certain bacteria dissimilate citrate anaerobically to acetate and oxaloacetate[1–4]; the reaction is of particular interest since, unlike citrate biosynthesis, it is not dependent on coenzyme A[1,2]. We have partially purified extracts of *A. aerogenes* and have demonstrated the following properties of citridesmolase: (1) As the reaction proceeds, the enzyme is progressively inactivated and ceases to function with citrate in excess. The amount of citrate decomposed

is proportional to the amount of enzyme present. (2) Oxaloacetate inhibits the reaction powerfully. Acetate and pyruvate (a product of the action of crude preparations) do not. (3) The enzyme is activated by certain divalent ions, notably magnesium, zinc and ferrous iron. (4) Calcium ions do not activate, but they inhibit the action of magnesium ions competitively. Bobtelsky and Jordan[5] proposed the structure (I) for chelate compounds between certain divalent metal ions and citrate, and they demonstrated that the hydrogen atom of the co-ordinated hydroxyl group was labile. On this basis a mechanism for citrate dissimilation by the enzyme is suggested (II).



(I)



(II)

The mechanism would account for the role of divalent metal ions in activation and competitive inhibition; and if there is a tendency for oxaloacetate to remain on the active site as shown, it would explain the observed inhibition by this product of reaction and the progressive inactivation that occurs. The asymmetric decomposition of the citrate molecule is a consequence of its three-point attachment. It has been suggested[6] that a chelate compound involving ferrous iron and citrate participates in the aconitase system.

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Production of Pyruvate from 6-Phosphogluconate by Bacterial Plant Pathogens and Legume Bacteria

In the course of investigations on the metabolism of phytopathogenic and root-nodule bacteria, it was observed that certain species of the former, and all species tested of the latter group of organisms, produced pyruvate from 6-phosphogluconate, and from glucose-6-phosphate plus triphosphopyridine nucleotide. Accompanying the formation of pyruvate was the appearance of triose phosphate. These results suggested that the 6-phosphogluconate was being metabolized in a manner similar to that reported recently with *Pseudomonas saccharophila* by Entner and Duodoroff[1] and MacGee and Duodoroff[2], and with *P. fluorescens* by Wood and co-workers[3]. These observations were confirmed by the fact that the intermediate in this pathway, 2-keto,3-deoxy,6-phosphogluconate (kindly supplied by Dr. MacGee, of the University of California, Berkeley, Calif.) was also split by cell-free extracts of our cultures to pyruvate and triose phosphate.

In these experiments cultures were grown in a fluid medium containing 1 per cent yeast extract and 2 per cent glucose in Fernbach flasks on a rotary shaker at 26° C. The cells were harvested after 20 hr., washed twice in tap water and suspended in four times their wet weight in distilled water. They were then subjected to sonic vibration in a Raytheon oscillator (10 kc./sec.) for 5–10 min. and the debris removed by centrifugation at 10,000 r.p.m. for 10 min. Pyruvate was determined either by the direct or by the double extraction methods of Friedmann and Haugen[4] and was further identified as the hydrazone by descending paper chromatography in a butanol–ammonia solvent, as described by Cavallini *et al.*[5]. Triose phosphate was determined as alkali-labile phosphorus[6]. Protein was estimated by means of the Folin phenol reagent as outlined by Lowry *et al.*[7].

Representative species of the major groups of plant pathogenic bacteria were tested: *Xanthomonas*, *Pseudomonas*, *Agrobacterium*, *Corynebacterium* and *Erwinia*. All species of the first three genera were capable of carrying out the above reaction. *Agrobacterium radiobacter* also gave a positive result. None of the species of *Corynebacterium* or *Erwinia* used (*C. fascians*, *C. flaccumfaciens*, *C. michiganense*, *E. carotovora*, *E. amylovora*) was found to split 6-phosphogluconate in this manner. All species of *Rhizobium* studied (*R. leguminosarum*, *R. trifolii*, *R. meliloti* and *R. phaseoli*) produced pyruvate from 6-phosphogluconate. A summary of the results obtained with certain of the bacterial species tested is given in Table 1.

Table 1. Production of Pyruvate from 6-Phosphogluconate. The reaction mixture contained: 0·1 ml. tris(hydroxymethylamino-methane) buffer *M*/1, *p*H 7·7; 0·1 ml. *M*/20 6-phosphogluconate; 0·1 or 0·2 ml. sonate; water to 1 ml.; it was incubated at 35° C. for 30 min. and the reaction stopped by addition of 1 ml. of a 0·1 per cent solution of 2,4-dinitrophenylhydrazine in 2 *N* hydrochloric acid

Organism	Pyruvate (μM per 10 mgm. protein)
Xanthomonas phaseoli	4·0
Pseudomonas angulata	4·2
Agrobacterium rubi	3·0
Corynebacterium fascians	0
Erwinia carotovora	0
Rhizobium phaseoli	2·5
Rhizobium meliloti	1·8

The importance of this course of hexose phosphate utilization remains to be assessed. For the species of *Xanthomonas* and *Pseudomonas* studied, it may be a major pathway, since little if any 6-phosphogluconate dehydrogenase activity has been demonstrated in sonates of these organisms as determined by measuring reduction of tri-(or di-)phosphopyridine nucleotide at 340 mμ in a Beckman *DU* spectrophotometer.

Details of these experiments will be reported elsewhere. I am indebted to Dr. W. A. Wood, of the University of Illinois, Urbana, Illinois, for

suggestions concerning biochemical methods used in this work.

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Inhibiting Effect of Trypan Blue on the Experimental Production of Liver Cancer

Recently, Gillman *et al.*[1] and Simpson[2] reported that trypan blue injected subcutaneously into rats at weekly or bi-weekly intervals induced tumour (reticulum cell sarcoma) of the liver. Trypan blue is a sulphonated dis-azo dye and somewhat resembles in chemical structure dimethylaminoazobenzene, which is a potent carcinogen for the liver of rats.

The present communication deals with the results of the subcutaneous injection of trypan blue on the incidence and course of tumours induced by *p*-dimethylaminoazobenzene. In these experiments 1–2 ml. of a 1 per cent aqueous solution of trypan blue was injected subcutaneously at intervals of one to two weeks into rats of mixed breed weighing 80–100 gm. which were also given 0·06 per cent dimethylaminoazobenzene diet. The injections were continued until a total dose of 60–80 mgm. of trypan blue had been given. The control animals were given 0·06 per cent dimethylaminoazobenzene diet, but received no trypan blue. The basal diet consisted of unpolished rice and contained 1·33 mgm. of riboflavin per kgm., which encourages tumour induction and survival, and this was supplemented by green vegetables every two days. The dimethylaminoazobenzene given to each rat amounted to about 600–700 mgm. over a period of six to twelve months. The experiments were terminated within one year and the incidence of liver cancer of the group injected with trypan blue was compared with the controls at periods of 6, 7–8 and 9–12 months after the commencement of the experiments.

These results indicate that trypan blue delays the production of liver cancer by *p*-dimethylaminoazobenzene. In the controls, the induced liver cancer reached a great size after six months and often metastases appeared in the abdominal lymph nodes and lungs. In the groups of animals which received trypan blue for seven to eight months, the tumour incidence amounted to 33 and 100 per cent respectively; but these tumours were much smaller and more localized compared with the controls, in which the tumour incidence was practically 100 per cent. During early trypan blue treatment, the rats showed less gain in weight and higher mortality due to respiratory infections than the controls, suggesting toxicity of the drug, while after five to six months they showed a considerable gain in weight whereas the controls showed a sustained loss.

Histologically, a marked hepatic response could be observed in the liver of treated groups. During the first one to two months, the stellate cells in the liver sinusoids were large and plump, and filled with trypan blue particles, whereas in the later months of the experiment a characteristic proliferation of the histiocytic cells developed in the portal tracts with the stellate cells growing smaller and narrower. The hyperplasia and hypertrophy of the parenchyma cells of the liver, however, were more inhibited than in the controls.

Recently, Miller *et al.*[3] have shown that the levels of protein-bound carcinogenic azo-dyes in the liver are lower when the carcinogen is fed in diets containing high levels of riboflavin. We measured the total protein-bound dimethylaminoazobenzene in the livers of the animals receiving trypan blue and in the control animals, using the method of Miller *et al.*[4]. It was found that the difference in the two groups of animals was too small to explain the inhibiting effect of trypan blue. *p*-Dimethylaminoazobenzene, however, was found in a slightly higher concentration in the trypan blue group, which suggests that trypan blue does not reduce the absorption of dimethylaminoazobenzene from the intestine or increase the rate of metabolism of it in the liver.

We wish to thank Profs. Fukuzo Oshima and Kazuo Hotta for their encouragement and advice.

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Determination of the Life of Human Blood Platelets using Labelled Di*iso*propylfluorophosphonate

Hitherto no satisfactory method for the determination of the life of blood platelets has been described. Recently a method has been reported for determining the life of erythrocytes using di*iso*propylfluorophosphonate labelled with phosphorus-32[1]. This method was based on the irreversible combination of this compound with esterases present on the red cell membrane. Since thrombocytes have also been shown to contain esterase, the same method suggested itself as a way of measuring the life of these cells. It seemed reasonable to assume that conditions similar to those described for red cells would be met. This implies that the decay of radioactivity associated with platelets would be entirely due to the destruction of these cells and therefore an index of their normal breakdown. This would only be true if no re-incorporation of labelled material in newly formed platelets were to take place. This assumption seems justified, since it has been shown that the only demonstrable metabolite of di*iso*propylfluorophosphonate in the human body is di*iso*propylphosphate. This compound is not further metabolized but quickly excreted in the urine. The labelled di*iso*propylfluorophosphonate used was synthesized by Mr. Oosterbaan (M.B.L., Rijswijk) by a method to be reported in the near future.

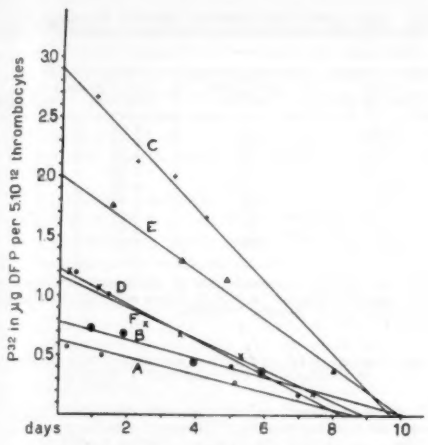

Fig. 1

The labelled di*iso*propylfluorophosphonate was administered as before[1]. From venous blood drawn into siliconized tubes using sodium sequesterene as anticoagulant, platelets were separated by a method of differential centrifugation. Every care was taken to avoid any contamination of the final platelet suspension with other formed elements of the blood. After determination of the cell concentration, the plasma was removed from a known volume of the final suspension. The resultant platelet mass was washed three times with physiological saline and hydrolysed for 30 min. at 100° C. in 3 ml. 30 per cent sodium hydroxide. The volume was made up to 11 ml. The radioactivity of this final solution was measured as described previously using a Geiger–Müller liquid counter. By relating the measurements to controls obtained by alkaline hydrolysis of labelled di*iso*propylfluorophosphonate of known radioactivity, it was possible to determine the di*iso*propylfluorophosphonate content of the measured sample. The same sample was used for the determination of the nitrogen content (Kjeldahl).

Measurements of platelet-bound radioactivity after injection of the labelled phosphonate was carried out at intervals in four normal persons (*A*, *B*, *C* and *D*), one patient with chronic myeloid leukæmia (*E*) and one patient with polycythæmia vera (*F*). The results are shown in Fig. 1. The curves are drawn by the method of least squares. The activity is expressed in micrograms di*iso*propylfluorophosphonate per 5×10^{12} platelets. The results show that the decline of the activity follows a straight line, indicating the existence of a real life rather than random destruction. The slope of the curve obtained suggests this life to be approximately nine days. Similar curves are obtained when the activity is expressed per gram platelet nitrogen. This figure might possibly be in some cases somewhat exaggerated due to contamination with radioactivity from other cells. This contamination reveals itself sometimes in a slight residual activity after the ninth day. However, such activity is so small that it cannot account for an exaggeration of more than one day. The life of the platelet should therefore be estimated at eight to nine days. Large variation in radioactivity and in amounts of di*iso*propylfluorophosphonate used occurred in these experiments. These facts suggest that toxic action or radioactivity does not seriously interfere with the life of the platelets under our conditions. A more detailed account of the method will be published elsewhere.

We are indebted to Miss C. H. Posthumus for technical assistance.

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Plant Hyperplasia induced with a Cell-free Insect Extract

Although the mechanism of plant-gall formation by insects has long provided a field for speculation, there are few records of attempts to induce such growths experimentally. The range of successful essays is practically limited to trials with Cecidomyid larval secretions and egg extracts in lanolin, injections of salivary gland extracts from a Coccid and *Adelges abietis*[1], and Martin's reproduction of pseudo-galls on sugar-cane with whole-insect extracts of a Jassid and other insects[2].

In the present experiments, Martin's technique was used in principle. Mature larvæ of two generations of *Dasyneura urticae* Perris (Diptera : Cecidomyiidae), which causes unilocular, slightly hairy galls on leaves, stems and flowers of *Urtica dioica*, were taken from sectioned galls and macerated in distilled water to give an extract of 50 larvæ/ml. In a second series, only larval heads were used. The macerate was filtered under slight vacuum, and the cell-free extract injected at once with an ultra-fine hypodermic needle into leaf bases of *U. dioica*, using the three youngest leaves on each stem. Attention has been directed[3] to the technical difficulty of directing the stimulus to the cambium ; but it has also been held[4] that pre-existing meristems are not necessarily implicated in gall initiation, all cells having a reaction potential to stimuli.

Out of a hundred and fifty injections with whole larva extract, and fifty with head-only extract, growth at the site of injection was noted within seven days in twelve and nine instances respectively, suggesting that the head provided the stimulant. No growth occurred in fifty water-injected controls. The growths did not resemble normal galls of *D. urticae*, probably because of the short-lived impact of the stimulant. The thickness of the parenchyma was increased by from two to five cells, with the epidermis consequently slightly raised. Kataplastic hyperplasia was thus demonstrated, but no nuclear irregularities were observed. (Longitudinal cell division has been described in *D. urticae* galls by Meyer[5].) No further growth occurred, nor was there subsequent reabsorption.

Although the results do not resolve the problem as to whether gall formation is initiated by an insect secretion or by a plant response, they do show that cell division is promoted by a chemical present in fully grown larvæ of a host-specific Cecidomyid. The zoological contribution to gall formation is therefore not confined to stimulants introduced at the time of oviposition or secreted only by newly hatched larvæ.

A detailed account of this work will appear elsewhere when studies with a prolonged stimulus have been completed.

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Colloid Osmotic Pressures of Dextran, Serum and Dextran–Serum Mixtures

The polysaccharide dextran is widely used for expanding the plasma volume or augmenting the colloid osmotic pressure of patients in whom the total circulating protein is reduced. No direct measurements have as yet been reported on mixtures of serum with dextran, although measurements made by Wales *et al.*[1] on dextran–albumin mixtures are in conformity with the results described here.

Colloid osmotic pressure measurements have been made with a new instrument[2] which uses a mechano-electronic transducer to detect movements of very small volumes of fluid across a semi-permeable membrane. In order to obtain reproducible results, it was found necessary to prepare nitrocellulose membranes which were substantially impermeable even to the smaller dextran molecules in the batch investigated. With these membranes the osmotic pressure did not alter significantly between 30 min. and 16 hr. When using membranes which were permeable to some dextran molecules but still impermeable to the serum proteins, it was found that the osmotic pressures, even on extrapolation back to zero time, might be considerably lower than those measured with the impermeable membranes. This observation agrees with that of Grim[3], who used glucose and leaky nitrocellulose membranes.

Fig. 1 shows the relationship between colloid osmotic pressure and colloid concentration for a transfusion batch of dextran ('Dextraven' batch 3525), normal human serum, and a mixture containing dextran and serum proteins in the ratio 43 to 57. The plot for dextran is sharply curved, so that only at low dextran concentrations can the colloid osmotic pressure be regarded as a simple function of the number average molecular weight (M_N). The plot for serum is less curved, and at low concentrations has a gradient similar to that of the dextran, that is, M_N for the two colloids is similar.

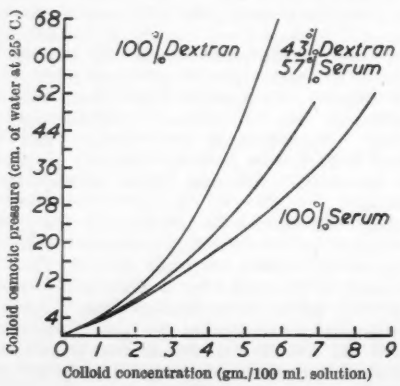

Fig. 1

Table 1. Calculated and Observed Colloid Concentrations of Dextran–Serum Mixtures for Various Colloid Osmotic Pressures

Colloid osmotic pressure (cm. water at 25° C.)	Dextran percentage of total colloid	Colloid concentration (gm./100 ml. solution) Observed	Calculated
50·0	43	6·85	6·90
25·5	43	4·55	4·55
9·6	43	2·30	2·30
17·5	60	3·26	3·35
28·7	69·5	4·24	4·45
38·9	53	5·53	5·70
16·6	27·5	3·57	3·60
22·4	20	4·87	4·65
35·8	33·5	5·85	5·95

'Calculated' colloid concentrations of mixtures are derived from observed concentration curves of pure serum and pure dextran giving corresponding colloid osmotic pressures.

Table 2. Colloid Osmotic Pressure Increment due to Presence of Dextran in Dextran–Serum Mixtures

Serum protein Concentration (gm./100 ml. solution)	Colloid osmotic pressure (cm. water at 25° C.)	Increment in colloid osmotic pressure due to dextran concentration in mixture (gm./100 ml. solution) 1 per cent	2 per cent	3 per cent	4 per cent	5 per cent
0	0	4	9·5	17·5	30	48
1	4	4·5	10·5	21	35	—
2	8	5·5	13·5	25·5	39·5	—
3	12	6·5	16·5	30·5	—	—
4	16·5	8	19·5	36·5	—	—
5	22	10	24	—	—	—
6	28·5	12	—	—	—	—
7	36	15	—	—	—	—
7·5	40·5	—	—	—	—	—

The curve for the dextran–serum mixture lies between those for dextran and serum; for any given colloid concentration the curve for the mixture (nearly half of which is dextran) indicates a colloid osmotic pressure much closer to the serum than the dextran. But inspecting the position of the curves for any given colloid osmotic pressure, the colloid concentration of the mixture is seen to have a value approximately midway between the corresponding dextran and serum values. This finding encourages the view that calculations might be based, for any value of colloid osmotic pressure (p), on the expression:

$$[\text{dextran}_p]\,x + [\text{serum}_p]\,(1-x) = [\text{mixture total colloid}_p]$$

where $[\text{dextran}_p]$, $[\text{serum}_p]$, etc., are the concentrations of dextran, serum, etc., giving an osmotic pressure of p, and x is the proportion of dextran in the final mixture. In Table 1 the results of a number of such calculations are shown which are in reasonable agreement with the corresponding experimental determinations.

This expression has been used for calculating Table 2, which shows that doubling the dextran concentration at any serum protein-level more than doubles the osmotic pressure increment due to the presence of dextran, and also that the lower the serum protein concentration the less the increment of osmotic pressure from any given dextran concentration.

The number average molecular weight of the dextran cannot therefore be used to calculate the expected osmotic pressure increment, and, in fact, a 2 per cent dextran of M_N about 300,000 in the presence of 3 per cent serum proteins gave an osmotic pressure increment of 14 cm. of water compared with 16·5 cm. of water for the transfusion batch of M_N about 80,000.

These results indicate that the initial colloid osmotic effect of a given dose of dextran is likely to depend not only upon its number average molecular weight, but also upon its osmotic pressure/concentration curve and the concentration of the plasma proteins. In addition, the permeability of the capillary walls may be such that the maximum possible osmotic pressure is not exerted across them even before much dextran has leaked into the extracellular fluid.

Loss of dextran into the urine, which always occurs with the currently available preparations due to their content of low molecular-weight material, also complicates any attempt to make exact predictions of *in vivo* effects from *in vitro* measurements.

I thank Prof. J. R. Squire for his interest. Samples of dextran were generously supplied by Messrs. Bengers, Ltd., and Messrs. Glaxo Laboratories, Ltd. This work was done during the tenure of a grant from the Medical Research Council.

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Separation of Flavins by Ion-Exchange Resins

Flavin compounds have been separated from each other by using a chromatopile[1], by using various kinds of adsorption and partition chromatography[2], and by chromatography on powdered cellulose[3]. A simpler and easier method using an ion-exchange resin is described in this communication.

Using an anion-exchange resin, Cohn *et al.* have reported the separation of adenosine and adenosine mono-, di- and tri-phosphates[4], and that of choline and its ester[5].

For the separation of flavin compounds by ion exchange, several ion exchangers were examined, and the anion-exchange resin, 'Dowex-1', was found to be the most suitable. 0·5 gm. of the resin of 100 ~ 150 mesh was placed in a brown-coloured glass tube of 8-mm. diameter, making a bed of depth 20 mm. After conversion of the resin to salt-type, the aqueous solution containing a mixture of flavin compounds was passed through at a flow-rate up to 2 ml./min., and the flavins were adsorbed. Free riboflavin and flavin mononucleotide used in these experiments were chemically synthesized crystals, and flavin adenine dinucleotide was prepared from hog liver by the method of Warburg and Christian[6] and purified in a chromatopile[1].

The exchanger column was fractionally eluted with aqueous salt solutions at a flow-rate of 2 ml./min. by changing the concentration of the salt in the solvent or changing both the concentration and *p*H of the solvent.

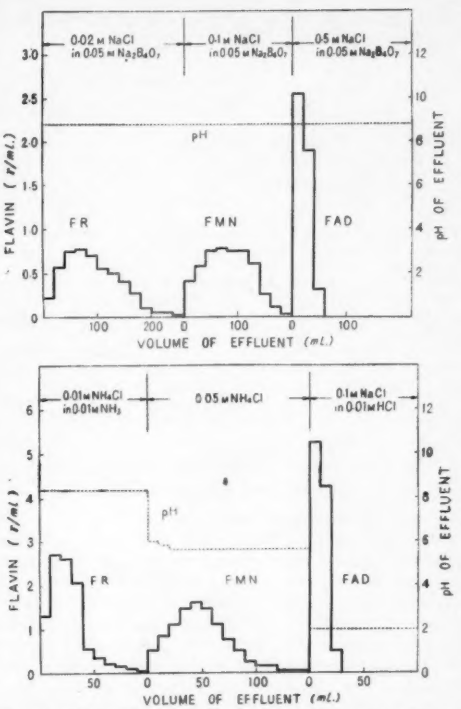

Fig. 1. Anion-exchange separation of flavins: bed, 'Dowex-1 × 4', 100 ~ 150 mesh, 50 mm.² × 20 mm.; flow-rate, 2 ml./min.

The two fractional elution procedures were as follows: (1) Change in the concentration of the salt. The resin was washed with 0·05 *M* borax (*p*H 8·8), and a solution containing 100γ each of riboflavin, flavin mononucleotide and flavin adenine dinucleotide in 0·05 *M* borax (*p*H 8·8) was adsorbed on the resin. Riboflavin was obtained on elution of the resin with 0·05 *M* borax containing 0·02 *M* sodium chloride, flavin mononucleotide with borax solution containing 0·1 *M* sodium chloride and flavin adenine dinucleotide with borax solution containing 0·5 *M* sodium chloride.

(2) Change in the concentration of salt and *p*H of the solvent. After the resin has been washed with 0·01 *M* ammonium chloride in 0·01 *M* ammonia aqueous solution (*p*H 8·4), and the solution of 100γ of each of the flavins dissolved in the above-mentioned solution was passed through, riboflavin was not adsorbed and immediately obtained as the initial effluent. Then, from the flavin mononucleotide and flavin adenine dinucleotide adsorbed, the former was obtained on elution of the resin with 0·05 *M* ammonium chloride at *p*H 5·6, and the latter with 0·1 *M* sodium chloride in 0·01 *M* hydrochloric acid at *p*H 2·0.

In these experiments, flavin compounds were identified by paper chromatography[7] and the quantities present determined by the lumiflavin fluorescence method[8]. The results are shown graphically in Fig. 1. These graphs show that the flavin compounds were separated completely from each other, and that the methods described can be applied for the fractional determination of the nucleotides

of riboflavin and the purification of flavin adenine dinucleotide.

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Circular Chromatography of Terpenes on Adsorbent Coated Glass

The 'chromatostrip' method of Kirchner, Miller and Keller[1] for the separation and identification of terpenes and related compounds is a useful technique in a field where chromatography has been little applied. The method consists essentially of coating glass strips with an adsorbent (silicic acid), oven-drying and cooling *in vacuo* over potassium hydroxide. The oil is spotted near one end of the strip, which is developed by capillary ascent in a similar manner to paper strips. Spots or zones are located by spraying with reagents, one of the most useful being concentrated sulphuric acid, with which most components of essential oils give characteristic colours. Kirchner *et al.* have indicated the usefulness of the method for two-dimensional chromatography, and Reitsema[2] has used glass plates on which a number of oils were directly compared.

In this laboratory the method has been adapted to the circular technique first described by Rutter[3] and has resulted in better resolution of zones, with the added advantage that as many as six oils may be conveniently compared on one plate. 'Magnesol' (hydrated magnesium silicate) has given better results than silicic acid.

Circular glass plates (5½ in. diameter) are coated with the adsorbent in a similar manner to that described by Kirchner *et al.*[1], except that 'Magnesol' is used instead of silicic acid. The plates are dried for ½ hr. at 105° C. and cooled for ½ hr. under vacuum over potassium hydroxide. The plate is then spotted at its centre with the oil to be examined, and placed adsorbent side down over a 5-in. diameter Petri dish containing a few millilitres of solvent. In the centre of the Petri dish a $\frac{1}{16}$-in. diameter cotton wick, held upright by passing it through a hole in a metal support, feeds the solvent on to the plate at the oil spot. A wooden jig is used for centring the wick and the plate accurately. The movement of the solvent can be seen through the glass and the position of the solvent front is marked with a glass pencil on the upper side of the plate. When measuring R_f values, the adsorbent is scraped off the glass above the pencil marks. Rate of development is controlled by the diameter of the wick and its degree of contact with the plate. About thirty minutes development gives good resolution for a radius of 2¼ in. from the point of contact.

The method has proved most useful in comparing the essential oils of hybrid *Eucalyptus* species with those of the parent trees.

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Inverted Rhythmic Precipitation

Many examples of rhythmic precipitation occur in geological and biological formations, where the separation of the rings of precipitate (of copper carbonate, calcium phosphate, etc.) decreases with the direction of diffusion of flocculating solution; and these have not generally been considered true cases of the Liesegang phenomenon[1]. The laboratory techniques[2,3] that are generally used for the study of rhythmic precipitation *in vitro* have always led to the typical spacing relation, for X_{n+1}, the position of the $(n + 1)$th ring,

$$X_{n+1} = (d_n - d_0) = ak^n \qquad (1)$$

where d_0, d_n are the distances of the first and $(n + 1)$th ring from the origin of diffusion[4]. With such techniques, X_n always increases geometrically with n, as the concentration of coagulating ion gradually decreases along the diffusion path[3,5]. When the diffusing ion, on the other hand, acts as a peptizer, no precipitation is observed.

I have developed a new technique for obtaining inverse rhythmic precipitation, similar to that observed in many natural formations. The ammonia-peptized sol of an insoluble metal salt dispersed in a fluid gelatine suspension is coagulated by diffusing a mixed solution of acetic acid, together with a third peptizing ion of slower rate of diffusion, into the set gel (cf. ref. 6).

The concentration of peptizer is greatest at planes nearest to the origin of diffusion, and the separation of the rings now decreases with n.

The following results have been obtained with 0·005 *M* silver chromate sols peptized by 0·050 *N* ammonia, in 5 per cent dialysed gelatine gels. 1 c.c. of the mixed solution was diffused into 15 c.c. of gel contained in test-tubes, and the precipitation observed for six to eight days. Measurements of d were made with a cathetometer[3].

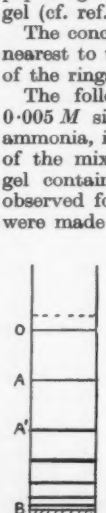

Fig. 1

Peptizing cation. (i) Precipitation with acetic acid plus copper nitrate solution. Over the range of concentrations, 2 *N* − 0·5 *N* acetic acid, 0·5 *N* − 0·1 *N* cupric ions, silver chromate is precipitated as a normal series of rings[6], followed at the plane *A* (Fig. 1), about 2 cm. from the origin of diffusion (*O*), by a series of rings of large silver chromate crystals. These rings become closer together along the diffusion path; and at a plane *B*, at distance d_∞ from *O*, a band of flocculated precipitate is formed. The distance (X_n) of the *n*th ring from *A* is now given by the relation,

$$X_n = (d_\infty - d_n) = ak^{-n} \qquad (2)$$

where a and k are constants. d_n is the distance of the nth ring from O (as in equation (1)). a has now a geometrical significance, and is equal to AB, the separation of the first two rings. Values of d_∞, a and the spacing coefficient $(k-1)$ are given in Table 1.

Table 1. INVERSE PRECIPITATION OF $M/200$ SILVER CHROMATE

	d_∞	a	$(k-1)$
2 N Acetic acid			
plus 0·5 N cupric ions	4·2 cm.	2·0 cm.	0·234
0·2 N „ „	2·7	0·8	0·100
0·1 N „ „	1·5	<0·2	<0·020
1 Acetic acid			
plus 0·2 N cupric ions	fully peptized		>1·000
0·1 N „ „	4·0 cm.	1·7 cm.	0·450

(ii) Precipitation with acetic acid plus lead nitrate solution. The usual rings of silver chromate first formed by the rapidly diffusing acetic acid are in turn gradually changed into rings of lead chromate which form by displacement (unpublished work). These latter are then peptized by excess lead ions. After 16 hr., a system of inversely stratified lead chromate precipitate appears on a background of yellow sol, over the range $N - 0{\cdot}1\,N$ acetic acid, $0{\cdot}5\,N - 0{\cdot}1\,N$ lead ions.

The rhythmicity is not sufficiently clear for accurate observations to be made without photoelectric instruments.

Peptizing anion. (iii) Precipitation with acetic acid plus potassium iodide solution. As in (ii), the silver chromate first formed is displaced by rings of silver iodide, which are in turn peptized to form an inversely precipitated system of pale yellow silver iodide rings on a background of silver iodide sol. For this system, also,

$$X_n = ak^{-n}$$

Values of d_∞, a and $(k-1)$ are given in Table 2.

Table 2. INVERSE PRECIPITATION OF $M/100$ SILVER IODIDE

	d_∞	a	$(k-1)$
5 N Acetic acid			
plus 0·5 N iodide ions	6·0 cm.	3·0 cm.	0·670
0·2 N „ „	4·6	2·0	0·462
0·15 N „ „	3·4	1·0	0·380
2 N Acetic acid			
plus 0·5 N iodide ions	5·5 cm.	2·4 cm.	1·000
0·2 N „ „	3·4	1·5	0·591
0·15 N „ „	1·4	0·6	0·305
1 Acetic acid			
plus 0·5 N iodide ions	4·7 cm.	1·7 cm.	1·424
0·2 N „ „	2·9	1·0	0·825
0·15 N „ „	0·9	0·4	0·440

As in Table 1, with increase in the initial concentration (C_0) of peptizer, $(k-1)$, a and d_∞ all increase: with fall in initial concentration of acetic acid, the total extent of diffusion of the coagulant, and hence that of the silver chromate precipitation, decreases. d_∞ and a thus decrease; but since more free ammonia will now be present at any plane, the spacing coefficients still increase[6].

For any initial acetic acid concentration, $(k-1)$ varies with the value of peptizer concentration, according to the relation,

$$(k-1) = \overline{A} - \overline{B}/C_0 \qquad (3)$$

(see Fig. 2).

$\overline{A}$ is the spacing at infinite initial peptizer concentration, and increases inversely with concentration of acetic acid (C_{HAc}). The variation of $(k-1)$ with concentration of acetic acid at constant initial concentration of peptizer, indeed, follows the general

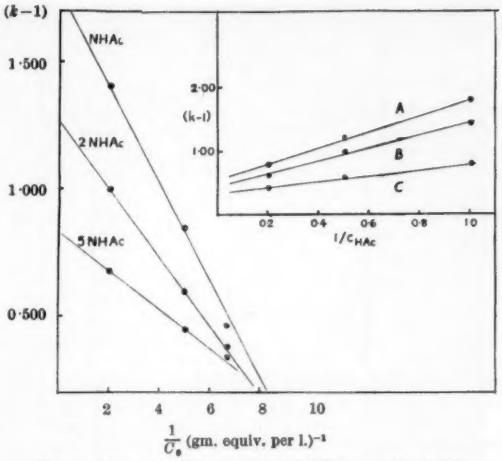

Fig. 2. Curve A, $\infty N1'$; curve B, $0{\cdot}5\ N1'$; curve C, $0{\cdot}2\ N1'$

relation, obtained for normal rhythmic precipitation[3],

$$(k-1) = A + B/C_{HAc} \qquad (4)$$

(see Fig. 2).

The above work was carried out at the Department of Physical Chemistry, King's College, London, during a period of postgraduate research. I wish to thank Sir Eric Rideal for his interest and helpful discussion.

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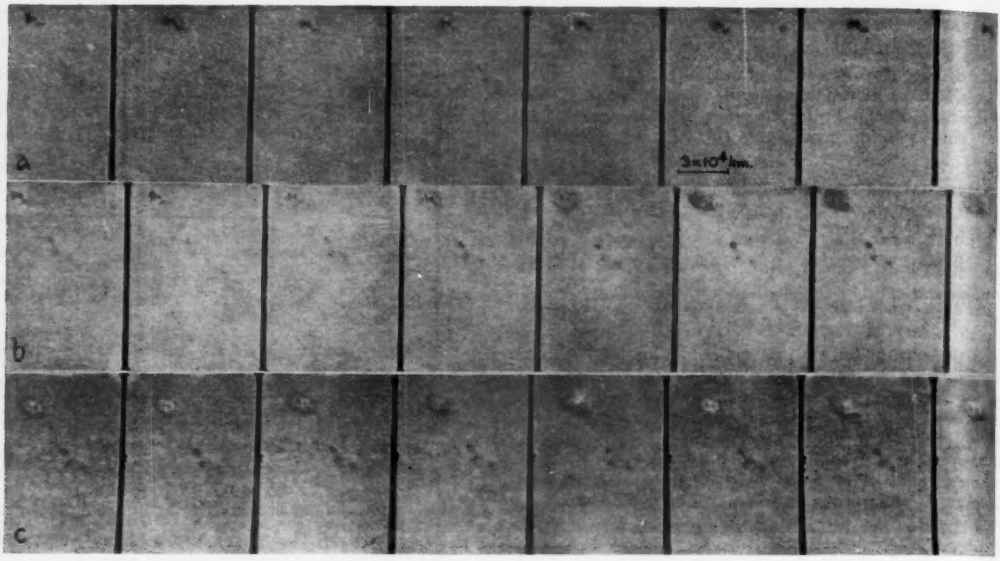
Intensity Variation in Sunspots

IN view of the observations of Dr. R. Ananthakrishnan[1] and his remark concerning the reality of the brightening of that part of the penumbra of a sunspot which is adjacent to the umbra, the attached print is of interest.

These photographs were taken on August 11, 1954, and are part of a ciné record of a sunspot group made between 14.15 and 14.30 U.T. The light-sensitive material was Eastman 548–*GH* emulsion coated on 16-mm. base. Exposure was made with a Bolex camera, without lens, situated at the focus of a 6-in. aperture, 480 in. focal length horizontal refractor. No filter was used, so that the spectral range recorded is from the ultra-violet cut-off of the optical equipment (about 3000 A.) to the limit of the sensitization treatment of the emulsion (about 5700 A.). The frame-rate of the motion-picture camera was 8 per sec., so that each strip has a total duration of one second, with the time increasing from left to right in each case. The shutter speed for each frame was 1/70 sec.

Strip (*a*) was taken very early in the series and shows very little penumbra and very little brightening immediately surrounding the umbra. Strip (*b*) was exposed about two minutes after (*a*). This strip shows



an abnormally bright region surrounding the umbra which is soon obscured or obliterated by the rapidly forming penumbra. Strip (*c*) was exposed about one minute after (*b*). Here the brightening next to the umbra is very much enhanced and appears to be almost the size of the penumbra, which is still well developed. The brightened area appears to be in violent motion. The speed shown by the 'flare' in frame 5 of (*c*) is of the order of 50,000 km. per sec., which would seem to prove that this is due to excitation rather than motion of material.

I have been unable to obtain solar noise records for 2,700–3,000 Mc./s. for the time during which the photographs were made. Some H_α flare activity was noted in this region during this time, but, to my knowledge, none occurred while the pictures were being taken.

This work was supported, in part, by the U.S. Army Signal Corps, under Contract No. *DA*36-039-*sc*-64524.

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Germanium in Power Station Boiler Plant

Crawley[1] has reported the results of a search for germanium in the waste products of the major coal-burning industries of Britain. We have determined the quantity of germanium in more than sixty samples of dust and deposits taken from various types of steam-raising plant within the British Electricity Authority; the results have not been encouraging.

In boilers fired with pulverized fuel, nearly all the ash from the fuel is carried forward with the flue gases, and it is therefore unlikely that appreciable enrichment of germanium will occur in the fly-ash. Analysis of several samples of fly-ash confirmed that the germanium content was very low, and even ash which had remained in the plant for some time, for example at the base of the chimney, was found to contain only 0·01 per cent. When the fuel is burned in a stoker-fired furnace, however, only a few per cent of the total ash in the fuel is carried forward and some enrichment due to condensation or adsorption on the fly-ash might be expected. The maximum concentration found in such ashes was only 0·015 per cent.

Selective condensation of inorganic constituents of the coal causes deposits to be formed in varying quantities throughout the boiler. It has been found that many of these deposits contain more germanium than the coals from which they were derived; but in only two, both from the superheater, was the germanium content greater than 0·1 per cent, which is the minimum concentration likely to repay recovery. The maximum concentration found was 0·16 per cent. Amounts between 0·05 and 0·1 per cent were found in ten out of forty samples of deposit taken from various parts of the system, including the induced-draught fans. The remainder of the deposits contained 0·003–0·05 per cent. It appears from these figures that deposits from steam-raising plant only occasionally contain useful amounts of germanium. Even then, the quantities of these deposits available are usually small; at most, about a ton could be recovered with some difficulty from one boiler in a year.

If the conditions of combustion and the constituents in the coal which affect the release of germanium could be determined, it might be possible to forecast which boilers were likely to have deposits rich in germanium. Experiments are therefore being made to see whether pyrites and the chlorides of sodium and potassium affect the release of germanium during the combustion of coal.

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Longitudinal and Screw Vibrations of Beams

RAYLEIGH'S method has been applied recently by us to examine the modes of vibration of beams and the relationships between the modes. One result of some interest is the interference with the fundamental modes of two types of oscillation which we have called 'screw vibrations'. These vibrations, although simple in nature, are generally ignored, perhaps because they have a minimum frequency of excitation.

Travelling waves in a circular cylinder can be distinguished, when the wave-length is considerably greater than the diameter, by the nodal surfaces, or the nodes in a normal cross-section. The fundamental modes of oscillation without nodes are the longitudinal and torsional modes. In addition, there are harmonics with nodal cylinders at a distance from the axis, and there are vibrations with nodal planes which cut the axis (there are other harmonics with both types of node). The first and second vibrations with nodal planes are the flexural and screw vibrations respectively.

If the z-axis is along the axis of the beam, and the axes OX, OY are principal axes of inertia of the normal cross-section with radii of gyration b, a respectively, then the displacements for the two screw vibrations from our approximate theory are:

(i) $u = \mathrm{A}\,x\sin(kz-\omega t)$, $v = -\mathrm{A}\,y\sin(kz-\omega t)$, $w = 0$
(ii) $u = \mathrm{B}a^2y\sin(kz-\omega t)$, $v = \mathrm{B}b^2x\sin(kz-\omega t)$, $w = 0$

for long wave-lengths. The name 'screw vibrations' was given since this seemed to describe the motion fairly well. It is also clear from (i) that the motion can be alternatively described as a squeezing motion, where the rod is squeezed first along the x-axis and then along the y-axis, and that (ii) can be described in the same way if the axes are rotated through 45°. For a circular or square beam these two vibrations are identical; but they are not for a rectangular or elliptical beam.

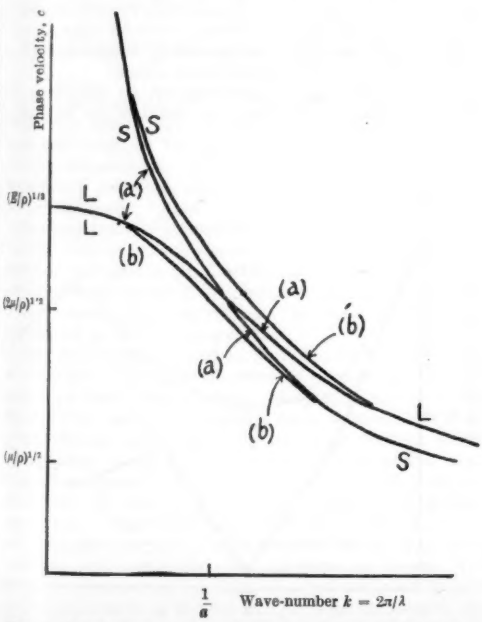

Fig. 1. Interference of longitudinal and screw vibrations. L = longitudinal type; S = screw type. (*a*) Circular or square beam; (*b*) elliptical or rectangular beam

The importance of these vibrations lies in the fact that they interfere with the longitudinal and torsional vibrations. In our approximate theory, as shown in Fig. 1, the dispersion curve of a circular cylinder for the longitudinal vibration cuts that for the screw vibration (i), when the phase velocity is $\sqrt{2}$ times the shear-wave velocity. Being of the same symmetry, the two interfere for a rectangular or elliptical cylinder. The result is that the fundamental mode, believed to be longitudinal, changes its character from longitudinal to screw as the wave-length passes through a value equal to the diameter of the beam, and the excited mode changes from screw to longitudinal. These conclusions have now been verified by exact calculations. They seem to be the first true example in this field of coupling between oscillations, the coupling constant being a shape parameter.

Evidence that this transition actually takes place is at the moment limited; but it should be easy to verify. It certainly agrees well with the observations of Morse[1] who, trying to excite longitudinal vibrations, found it much easier to obtain the higher branch at high frequencies. Also Mr. A. B. Lewis, in the Physics Department of this College, has been observing longitudinal vibrations using lycopodium powder and has found in one or two cases that the powder, instead of being distributed in rings about the axis of his cylinder, has lain in spirals at some places.

The second screw vibration (ii) interferes in the same way with the torsional oscillation. The approximate theory gives the interference without an actual intersection of the curves, but this intersection has since been found by Mr. A. Green, of this Department, in the course of some exact calculations of the torsional oscillations of non-circular beams.

In view of the simple form of the oscillation, it should be possible to devise an elementary or engineering theory of the screw oscillation; but this has not yet been done.

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An Interferometer for 'Straightness' Measurement

IT is sometimes required in engineering practice to measure the flatness of a surface, such as that of a surface plate, with considerable accuracy. A similar problem arises in checking the straightness of a mechanical motion, such as that of a lathe cutting-tool. To perform such a measurement with sufficient accuracy is not easy if the dimensions are too large to allow of an optical flat being used as a reference surface.

An interferometer has been constructed which enables such measurements to be made. The optical system, shown in Fig. 1, is based on two identical concave mirrors, separated by their common radius of curvature, so that the centre of curvature of each lies in the face of the other. The reference 'straight' is then defined by the line joining the two centres

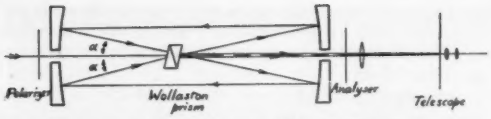

Fig. 1. Optical system of 'straightness interferometer'

of curvature. Light enters through a small hole in one mirror, and proceeds along the axis until it strikes a beam-splitting device, which may conveniently be a Wollaston prism. It is thereby divided into two beams which, after successive reflexion at the two mirrors, converge on to the prism once more. It is easy to show that this is the case for any axial position of the prism. Each beam is then refracted once more, and the two beams pass through a hole in the second mirror in a direction parallel with the axis and with each other, but separated by a small amount.

If the original beam be polarized at 45° to the principal directions of the prism, and an analyser placed in the beam upon its emergence from the system, interference fringes will be observed in the focal plane of a telescope. These fringes will move if the Wollaston prism be displaced at right angles to the axis in the plane of the diagram, but will not move for a displacement in any other direction. If the angle made by each beam with the axis be α, and the wave-length be λ, the displacement of the prism for a motion of one fringe of the fringe system will be $\lambda/(4 \sin\alpha)$.

In use, the prism may be mounted on a moving member of which it is desired to check the straightness of path, or suitably attached to a stylus which moves over the surface to be examined. The motion of the fringes then indicates the deviation of its path from the line of centres of the mirrors.

It is convenient to introduce a compensator to return the central white fringe to a fiducial mark in the eyepiece at each measuring point. The deviations are then read from a scale on the compensator.

An experimental model, using mirrors 3 in. in diameter and 20 in. apart, with a prism giving an angle α of about 0·06, gives a sensitivity of about 0·00008 in. per fringe, allowing a reading accuracy, if the compensator be set to one-tenth of a fringe, of about 8 micro-inches. It is found that successive runs are repeatable to about this figure.

The spherical aberration introduced by the two mirrors is not negligible but, because of the symmetry of the system, it does not give rise to any error.

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Effect of Time of Embryo Formation on Quantitative Characters in *Drosophila*

In preliminary studies on the causes of variability in pure lines of *Drosophila melanogaster*, using the quantitative character of sternopleural chæta number, it was noted that a relationship existed between chæta number and time of hatching. This could have been due entirely to changes taking place in the culture media[1,2], but experiments have now shown that some part of this variability is already determined before the eggs are laid and is, furthermore, inherited.

Pairs of flies taken from the Samarkand line, which has been sib-mated for more than three hundred generations, were transferred at 12-hr. intervals through a relay of six tubes to remove effects of staling media. The curve obtained on summing the results of several experiments repeated at different times ('Samarkand relay', Fig. 1) differs from the type of curve produced when no relay is employed, but may be related to the changes found by Robertson and Sang[2] to occur in the physiological activity of the female with advancing age. On taking several pairs of flies at 12-hr. intervals from an ordinary culture tube, and maintaining separate lines for three generations by mating flies from the respective hatching periods, the combined family means curve ('Samarkand time selection', Fig. 1) was found to be closely correlated with that of the 'Samarkand relay'. From this it appears that the variability determined prior to egg-laying is inherited; but, as one might expect, the response to environmental effects in the tube is not. Hence selection within an inbred line is possible.

The curve may be altered by taking parents, or grandparents in the first instance, from different hatching periods. If, therefore, parents are taken at random in replicating experiments of this nature, seemingly inconsistent results may be obtained, thereby leading to a conclusion of random variation. Oregon, a more prolific and long-lived inbred line, gives the same type of curve; but it is interesting to note that the curve is more pronounced and drawn out over the longer life-span. On this account alone Oregon must be considered a more variable line.

Under certain summations, chæta number shows a negative correlation with the number of flies hatching; but the relation is not complete and in some cases it may be positive. Should this be substantiated by further experiments, then it would appear that factors (presumably cytoplasmic) responsible can segregate independently of each other.

Age of parents has been shown to influence the character of the offspring in a number of organisms,

Fig. 1. Samarkand relay, ——; Samarkand time selection, - - - -

and recently Mather[3], in reviewing a symposium[4] on the subject, directs attention to the significance of those findings. Some further points of immediate interest follow. (i) A large part of the variability in at least two inbred lines of *Drosophila*, generally ascribed to residual heterozygosity or uncontrollable environmental variation, is governed by the time of embryo formation. In common with the lower organisms, *Lemna*[5], *Philodrina*[6] and *Aspergillus*[7], there is here an extra-chromosomal mechanism of inheritance. (ii) Greater emphasis must be placed on good sampling technique in taking flies for examination or mating. Taking flies from a set period is not advisable, since the time-effect not only varies with lines but also shows some interaction with generations. (iii) The use of an inbred control for removing some of the environmental variability from selection lines may increase their variability, since if the controls (c) and selection lines (s) are independent, or $V_c > 2W_{cs}$, then $V_{c-s} > V_s$. (iv) Stability of genotype, in the sense that it is normally applied, cannot be considered a complete interpretation of the relative variability of inbred lines and their crosses. It remains of considerable interest to assess how much may be apportioned to this.

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The Covering Reaction in a Tropical Sea Urchin

IT has long been known that certain littoral echinoids habitually cover the parts of their body that are exposed to light by fragments taken from their surroundings. Some have interpreted this as a concealing reaction, or, in part at least, as a response to strong light, or as a defence against desiccation and temperature extremes resulting from exposure at low tide; others remained non-committal. *Lytechinus variegatus* (Lamarck) shows the response in striking fashion[1] and, in Jamaica, in habitats where it is never exposed by tides. The response has been examined in these laboratories.

The individuals found in Jamaica differ noticeably in the depth of the green colour of the test and spines, pale and dark forms being present in about equal numbers in the populations I have examined. Both avoid strong light (especially the pale forms), either by seeking shade or by covering themselves with opaque fragments; if the shade or the material available for cover is scanty, both methods are employed. Naked forms transferred from shade to sunlight may begin to cover themselves in about two minutes and complete the process in about five minutes. In intense sunlight, the process is continued until the urchin is buried in the hole excavated by the removal of stones, shells, etc., used to form the cover.

The response has been ascribed to the activities of tube feet and pedicellariæ[2]; but I find no evidence of the latter taking part, each fragment being pulled down firmly against the tips of the spines by the tube feet attached to it. The number of tube feet involved depends on the weight of the object held, and if it is slightly displaced, additional tube feet are brought into play to hold it. These co-ordinated actions are still performed when the areas including the peristome or the periproct, and the lantern, together with all nerve elements associated with them, have been removed.

Light is a significant factor, since when it is directional, opaque objects are held against the source, and if the position of the latter is altered, the shading objects are moved accordingly. A shadow cast on the aboral or ambital regions produces a brief and rapid shortening of some tube feet, which then extend more slowly toward the shading object, adhere to it and hold it in the light path.

The covering is shed slowly and to varying degrees as the light intensity is reduced. In total darkness, a complete covering may be shed in 70 min.–3 hr.; but in some cases, one or two stones have been retained for as long as 19 hr. When light is re-admitted, the covering is picked up again with a speed which depends on the light intensity, the time the urchin has remained in darkness and its depth of colour (pale individuals covering themselves more quickly and more completely than dark ones).

A process of physiological adaptation may occur; urchins which have been compelled to remain uncovered in strong light cease to show the response, but may show it again after a sojourn in darkness.

The importance of light is shown by the effect of dyes such as eosin *Y*, bengal rose and neutral red, which, when dissolved in sea water or cœlomic fluid and injected into the perivisceral cœlom, photosensitize urchins so that they cover themselves in relatively dim light. The effect appears in 2–20 hr. and persists for four to seven days.

The work is being continued and will be published in full elsewhere.

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Breeding Systems and Compatibility in *Glyceria*

A LIMITATION of gene exchange by incompatibility between segments of an outbreeding species-population is of primary importance in micro-evolution[1], and few cases have hitherto been reported in the Gramineæ. Some results of a study of the species *Glyceria fluitans* and *Glyceria plicata* may therefore be of interest.

From both species, five widely separated local populations, each distinguished by minor morphological characters, were selected for intensive biosystematic investigation. Seed samples were collected by a suitable method[2], and the progeny grown in the experimental garden. All the plants had the somatic chromosome number $2n = 40$ usual in these species[3,4].

Table 1. Breeding Systems and Compatibility in *Glyceria*

	G. fluitans								*G. plicata*							
	Selfed		Open pollinated*		Crosses within populations		Crosses between populations		Selfed		Open pollinated*		Crosses within populations*		Crosses between populations	
	Heavy†	Light‡	Heavy	Light	Heavy	Light	Heavy	Light	Heavy	Light	Heavy	Light	Heavy	Light	Heavy	Light
Mean seed set (per cent)	27	46	67	19	62	16	1·2	2·5	81	6	84	4	76	12	75	9
Range (per cent)	8–58	13–67	65–71	6–23	51–75	12–19	0–9	0–10	69–97	4–9	81–86	2–6	68–81	7–17	70–81	6–12
Mean seed viability (per cent) (Heavy + light)	54		88		54		1·7		92		83		95		86	
Range (per cent)	2–90		87–90		50–58		0–21		82–100		65–97		90–100		80–95	

* Data from two populations only. † Heavy seed: grains of full size. ‡ Light seed: grains less than two-thirds full size.

Tests were carried out to determine self- and cross-compatibility within and between populations. Hand emasculation followed by 'automatic pollination' was adopted in making crosses[5]. Compatibility was assessed on the basis of seed-set and viability.

A varying degree of self-incompatibility from plant to plant is characteristic of outbreeding grasses[6]. Comparing the results obtained from selfing with those from uncontrolled outcrossing (Table 1), it can be seen that *G. fluitans* plants are to various extents self-incompatible. This is shown by the low percentage of heavy seed obtained on selfing. Seed viability is related to degree of self-incompatibility, germination being poorest in the most self-sterile plants. *G. plicata* plants are by contrast highly self-compatible.

Observations were made of behaviour at anthesis. In *G. fluitans* the florets opened briefly and the large pendulous anthers were fully exserted on long filaments prior to dehiscence, which occurred before the stigmas were fully expanded. The florets of *G. plicata* stood open, and the small anthers were borne out on rather stiff filaments, dehiscing above the fully expanded stigmas. These facts strongly suggest that *G. fluitans* is a predominantly outbreeding species, and *G. plicata* generally inbreeding. In the latter species, though pollination is required for seed setting, apomixis may occur to some extent.

The results of controlled hybridization indicate that, in *G. plicata*, plants derived both from the same and different populations are highly cross-compatible. By contrast, in *G. fluitans* the results of intra- and inter-population crosses differ markedly.

Seed set in intra-population crosses (62 per cent heavy seed) about equalled that obtained on outcrossing (67 per cent heavy seed); there was, however, some reduction in viability, 54 per cent as against 88 per cent on outcrossing.

In inter-population crosses, few or no seeds were set (1·2 per cent heavy seed) and the viability of these was poor (1·7 per cent).

This suggests that a degree of incompatibility exists between parts of the *G. fluitans* species-population, sufficient to limit or prevent gene-exchange. In both species the local populations sampled were distinct morphologically and perhaps equally well isolated from the micro-evolutionary point of view. Incompatibility occurs in *G. fluitans*, but is apparently absent from *G. plicata*, and this is probably related to the breeding systems of these species[7].

This work forms part of a biosystematic study of the British species of Sect. Euglyceria carried out at the University College of Leicester, the results of which will be given in full elsewhere.

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Arginase in Elasmobranch Muscle

Hunter and Dauphinee[1] demonstrated the presence of arginase in the voluntary muscle of the dogfish (*Squalus sucklii*) and also possibly in the muscle of the herring. In the course of another investigation, it has now been observed that this is not true of other elasmobranchs, since no arginase activity was found in the skeletal muscle of the common skate (*Raja batis*), thornback skate (*R. clavata*) or cuckoo ray (*R. circularis*) using the conditions of determination of Van Slyke and Archibald[2] with the colorimetric procedure of Engel and Engel[3]. Activity was, however, observed in both the ordinary 'white' skeletal muscle (0·3 arginase units[2]/mgm. extract nitrogen) and 'red' lateral-band muscle (0·75 arginase units/mgm. extract nitrogen) of the lesser-spotted dogfish (*Scyliorhinus caniculus*) (cf. the observations of Matsuura *et al.*[4] on several non-elasmobranch species of fish).

It seems that for the rays, at least, the extra-hepatic regulation of urea which appears to occur in elasmobranchs cannot take place in the muscle, even though this tissue is rich in urea.

J. J. Connell

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Dec. 2.

[1] Hunter, A., and Dauphinee, J. A., *Proc. Roy. Soc.*, B, **97**, 227 (1924).
[2] Van Slyke, D. D., and Archibald, R. M., *J. Biol. Chem.*, **165**, 293 (1946).
[3] Engel, M. G., and Engel, F. L., *J. Biol. Chem.*, **167**, 535 (1946).
[4] Matsuura, F., Baba, H. J., and Mori, T., *Bull. Jap. Soc. Sci. Fish.*, **19**, 893 (1953).

FORTHCOMING EVENTS

Monday, March 28

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Major P. L. Teed: "Fatigue". (Final Cantor Lecture on "The Mechanical Properties of Metals".)

Tuesday, March 29

ASLIB (at the Kingsley Hotel, Bloomsbury Way, London, W.C.1), at 2.30 p.m.—Conference on "The Information Officer in Industry".

Tuesday, March 29—Thursday, March 31

SOCIETY OF CHEMICAL INDUSTRY, NORTHERN IRELAND SECTION AND FOOD GROUP (in the Department of Geology, Queen's University, Elmwood Avenue, Belfast)—Joint Symposium on "Bacon".

Wednesday, March 30

CHEMICAL SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 10.30 a.m.—Symposium on "Peptide Chemistry".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Sir Robert H. Davis: "Recent Developments in Deep Sea Diving".

PHYSICAL SOCIETY, COLOUR GROUP (at the Royal Photographic Society, 16 Princes Gate, Kensington, London, S.W.7), at 3.15 p.m.—Annual General Meeting. 3.30 p.m.—Dr. L. C. Thomson: "The Part Played by Electrophysiology in the Investigation of Visual Mechanisms" (Chairman's Address).

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (in the Convocation Hall of Church House, Westminster, London, S.W.1), at 6.30 p.m.—Mr. F. L. Laque: "Attention to Corrosion in the U.S.A.".

ROYAL INSTITUTE OF CHEMISTRY (joint meeting with the CHELSEA POLYTECHNIC CHEMICAL SOCIETY, at the Chelsea Polytechnic, Manresa Road, London, S.W.3), at 7 p.m.—Mr. F. V. Davis: "Man-made Textile Fibres".

Wednesday, March 30—Friday, April 1

INSTITUTE OF PHYSICS, X-RAY ANALYSIS GROUP (at the University of Bristol, H. H. Wills Physical Laboratory, Royal Fort, Bristol 8)—Spring Conference.

Thursday, March 31

CHEMICAL SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 11 a.m.—Dr. Gunnar Randers (Norway): "The Outlook for Industrial Atomic Energy in Europe".

INSTITUTE OF REFRIGERATION (at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Symposium on "Modern Trends in the Storage of Fruit and Vegetables".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. E. W. Golding: "Electrical Energy from the Wind".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. T. D. Weatherhead: "Application of Aerial Survey to the Economic Development of a Country".

Thursday, March 31—Friday, April 1

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 9.30 a.m.—Symposium on "The Protection of Structural Steel".

Thursday, March 31—Saturday, April 2

PHYSICAL SOCIETY (at the Atomic Energy Research Establishment, Harwell)—Spring Meeting—"Neutron Physics and Energy Levels".

Friday, April 1

ASSOCIATION OF APPLIED BIOLOGISTS (in the Mining Lecture Theatre, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7), at 2.15 p.m.—Annual General Meeting; followed by Prof. W. Brown, F.R.S.: "The Physiology of Parasitism of Plants" (Presidential Address).

Friday, April 1—Sunday, April 3

ASLIB AERONAUTICAL GROUP (at the College of Aeronautics, Cranfield, Bletchley, Bucks)—Fourth Annual Conference.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER or SENIOR LECTURER IN MATHEMATICS, and a LECTURER or SENIOR LECTURER IN SCIENCE, at the Royal Military Academy, Sandhurst—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting 4434/55 (March 31).

METALLURGISTS (with a university degree or equivalent qualification in metallurgy, and preferably with experience in the behaviour of metals at high temperatures) in the Research Laboratories, British Electricity Authority, Leatherhead—Director of Establishments, B.E.A., Winsley Street, London, W.1, quoting AE.579 (March 31).

BIOCHEMIST (non-medical) IN THE DEPARTMENT OF CHEMICAL PATHOLOGY—The Secretary, Royal Free Hospital, London, W.C.1 (April 1).

SENIOR LECTURER (with special qualifications in inorganic and analytical chemistry) IN CHEMISTRY; a TEACHER OF CHEMISTRY; a TEACHER OF SCIENCE; and a TEACHER OF MATHEMATICS—The Principal, College of Technology, Belfast, N. Ireland (April 1).

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF ZOOLOGY—The Registrar, The University, Liverpool (April 2).

ORGANIC CHEMIST (preferably with experience in the structural chemistry of natural products), to assist in the investigation of the structure of certain hormone-like substances of plant origin—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting 55/5 (April 2).

SENIOR LECTURER (with at least an honours degree in metallurgy of a British university or equivalent, together with substantial experience in research or industry) IN THE DEPARTMENT OF METALLURGY, to be responsible for teaching advanced physical metallurgy to honours B.Sc. (metallurgy) and A.I.M. standards, and to participate in the postgraduate and research work of the Department—The Registrar, College of Technology, Suffolk Street, Birmingham 1 (April 2).

LECTURER IN MECHANICAL ENGINEERING, at the College of Technology and Commerce, Cardiff—The Director of Education, City Hall, Cardiff (April 5).

PRINCIPAL LECTURER or SENIOR LECTURER IN RADAR AND TELECOMMUNICATIONS OR ELECTRONIC INSTRUMENTATION; a LECTURER IN MECHANICAL ENGINEERING; a LECTURER IN ELECTRONICS at the Royal Military College of Science, Shrivenham—The Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S.4439/55 (April 7).

ASSISTANT VETERINARY INVESTIGATION OFFICER (Member of the Royal College of Veterinary Surgeons, and with experience of general veterinary practice among farm animals, and preferably with laboratory experience)—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (April 9).

EXPERIMENTAL OFFICERS and ASSISTANT EXPERIMENTAL OFFICERS (with at least H.S.C. (science) or equivalent) at the Ministry of Supply National Gas Turbine Establishment, near Farnborough, Hants, for problems of combustion, heat transfer, aerodynamics, projects and performance instrumentation, and application of electronics in gas turbine research—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.146/5A (April 9).

LECTURER (preferably with research experience in polymer science) IN CHEMISTRY—The Registrar, The University, Manchester (April 9).

LECTURER (with experience in electron microscopy) IN BIOPHYSICS—The Registrar, The University, Manchester 13 (April 11).

LECTURER (with a good degree in engineering and some industrial experience, and preferably some experience in engineering design) IN THE DEPARTMENT OF MECHANICAL ENGINEERING—The Registrar, The University, Liverpool (April 13).

CHAIR OF ANATOMY at the University College of Khartoum, Sudan—The Secretary, Inter-University Council, 1 Gordon Square, London, W.C.1 (April 15).

LECTURER IN EXPERIMENTAL PHYSICS; LECTURERS (2) IN ELECTRONICS; ASSISTANTS IN EXPERIMENTAL PHYSICS, THEORETICAL PHYSICS, and ELECTRONICS; and a LECTURER IN AGRICULTURE—The Secretary, The University, Aberdeen (April 15).

DIRECTOR (with veterinary qualifications and preferably a good degree in science) OF THE ANIMAL HEALTH TRUST FARM LIVESTOCK RESEARCH STATION, Stock, Essex—The Scientific Director, Animal Health Trust, 14 Ashley Place, Westminster, London, S.W.1 (April 18).

PHYSICISTS or MECHANICAL ENGINEERS (with a good honours degree in physics or mechanical engineering, considerable experience in research, and with scientific originality and initiative), with the National Coal Board, Isleworth, Middlesex, to lead teams being formed for the investigation of the technical processes of coal winning—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/943 (April 18).

LECTURER or ASSISTANT LECTURER (with a special interest in organic chemistry) IN CHEMISTRY—The Registrar, The University, Sheffield (April 23).

ASSISTANT LECTURER IN MATHEMATICS—The Registrar, The University, Hull (April 25).

CHEMIST (with an honours degree in chemistry (biochemistry or agricultural chemistry) of a British university, and some research experience)—The Director, Tea Research Institute of East Africa, P.O. Box 91, Kericho, Kenya (April 30).

LECTURER (Grade I) IN CHEMICAL ENGINEERING, at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (April 30).

LECTURERS IN EXPERIMENTAL or THEORETICAL PHYSICS—The Secretary of University Court, The University, Glasgow (April 30).

ASSISTANT LECTURER IN PHYSICS—The Registrar, University College of North Staffordshire, Keele, Staffs (May 1).

SENIOR LECTURER IN PLANT TAXONOMY, at the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 10).

ASSISTANT, Grade "B" (with graduate or A.R.I.C. qualifications) IN CHEMISTRY—The Principal, Technical College, Queen Street South, Huddersfield.

ASSISTANT LECTURER (with special interests in plant pathology) IN AGRICULTURAL BOTANY—The Bursar, Royal Agricultural College, Cirencester.

ASSISTANT TECHNICAL SECRETARY (male or female) (with a general science degree or equivalent qualification, and preferably with experience in metallurgical analysis, metallography or physical testing) IN THE METALLURGY DIVISION at the Association's London offices—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "Assistant Technical Secretary".

GRADUATE (with an honours degree in chemistry or metallurgy) to undertake research in the methods of preventing corrosion of iron and steel—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "Corrosion".

HEAD (with appropriate academic and industrial qualifications) of THE DEPARTMENT OF CHEMISTRY AND BIOLOGY, College of Technology and Commerce, Cardiff—The Director of Education, City Hall, Cardiff.

LABORATORY TECHNICIAN (with some knowledge of chemistry and experience in general workshop practice) whose main duties will be to take charge of Metallurgical Stores, and to prepare samples for laboratory classes—The Registrar, The University, Nottingham.

LABORATORY TECHNICIAN (with general and chemical laboratory experience, and preferably some botanical experience)—Professor of Botany, The University, Edgbaston, Birmingham 15.

LECTURER (with a good honours degree in metallurgy and preferably works experience) IN METALLURGY—The Registrar, The University, Nottingham.

LECTURERS (2) IN MATHEMATICS—The Secretary, Royal Technical College, Glasgow.

SENIOR LECTURER (specializing in stratigraphy–palæontology) IN GEOLOGY—The Dean, College of Arts and Science, Baghdad, Iraq.

CHAIR OF PHYSICS, and CHAIR OF GENERAL CHEMISTRY, at the Royal College of Medicine, Baghdad, Iraq—The Director, Personnel Department, The British Council, 65 Davies Street, London, W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 929, Vol. 247 (28 December 1954): Two-Dimensional Theory of Elasticity for Finite Deformations. By J. E. Adkins, A. E. Green and G. C. Nicholas. Pp. 279–306. 8*s*. 6*d*. No. 930, Vol. 247 (28 December 1954): The Asymptotic Solution of Linear Differential Equations of the Second Order for Large Values of a Parameter. By F. W. J. Olver. The Asymptotic Expansion of Bessel Functions of Large Order. By F. W. J. Olver. Pp. 307–368. 19*s*. (London: Royal Society, 1954.) [3112

Papers of the Royal Commission on Population. Vol. 6: The Trend and Pattern of Fertility in Great Britain—a Report on the Family Census of 1946. By D. V. Glass and E. Grebenik. Part 1: Report. Pp. iii+306. Part 2: Tables. Pp. iv+253. (London: H.M. Stationery Office, 1954). 70*s*. net the two parts. [3112

Institution of Gas Engineers. Publication No. 450: Origins and Development of Gas for Industrial Purposes. By Dr. Alexander Fleck. (Murdoch Memorial Lecture.) Pp. 26. Publication 452: 15th Report of the Chairman's Technical Committee, 1953–54. Pp. 16. Publication No. 453: Sixth Arthur Duckham Research Fellowship Report, 1953–54. Luminous Flame Radiation in a Smallscale Oil-fired Furnace. By E. P. Hotchen. Pp. 54. Publication 454: 31st Report of the Gas Education Committee, 1953–54. Pp. 29. Publication 457: The Production of Town Gas by the Catalytic Gasification of Petroleum Oils. 2: The Development and Operation of a Commercial Plant. By H. Stanier and J. B. McKean. Pp. 30. Publication 458: Disposal of Products of Combustion from Gas Appliances. By A. R. Bennett and H. Reichert. Pp. 37. (London: Institution of Gas Engineers, 1954.) [31

Federation of British Industries. Public School and Grammar School boys in Industry. Pp. 12. (London: Federation of British Industries, 1954.) 1*s*. [31

Ministry of Food. Food Standards Committee Report on Colouring Matters; Recommendations relating to the Use of Colouring Matters in Foods. Pp. 27. (London: H.M. Stationery Office, 1954.) 1*s*. net. [31

Modern Storage Equipment and Methods for Special Materials in Libraries. By Robert L. Collison. Pp. 32. (London: R. L. Collison, 7A, Worsley Road, N.W.3, 1955.) 2*s*. 6*d*. [31

Proceedings of the Royal Irish Academy. Vol. 56, Section A, No. 5: Production and Annihilation of Negative Protons—3. By the Rev. James McConnell. Pp. 45–66. 3*s*. 6*d*. Vol. 56, Section B, No. 4: Records from some Irish Lakes. Part 1: Mollusca, *Gammarus*, *Asellus*, Ephemeroptera, and Heteroptera. Part 2: Phytoplankton. By T. T. Macan and J. W. G. Lund. Pp. 135–158. 4*s*. Vol. 56, Section B, No. 5: The Geology of the Northern End of the Leinster Granite. Part 1: Internal Structural Features. By J. C. Brindley. Pp. 159–190+plates 5–7. 4*s*. 6*d*. (Dublin: Hodges, Figgis and Co., Ltd., 1954.) [31

Federation of British Industries. Fuel Economy Review, 1955. Pp. 100. (London: Federation of British Industries, 1955.) 5*s*. [31

Hull Bulletins of Marine Ecology. Vol. 3, No. 24: Continuous Plankton Records. The Young Fish and Fish Eggs, 1932–39 and 1946–49. By Dr. G. T. D. Henderson. Pp. 215–252+plates 20–27. 12*s*. 6*d*. Bulletins of Marine Ecology (formerly Hull Bulletins of Marine Ecology). Vol. 4, Nos. 27 and 28: Continuous Plankton Records. The Distribution of Lamellibranch Larvæ in the North Sea, 1950–51. By Dr. C. B. Rees. The Distribution of Echinoderm and Other Larvæ in the North Sea. By Dr. C. B. Rees. Pp. 21–67+plates 7–12. 12*s*. (Edinburgh: Scottish Marine Biological Association, 1954.) [31

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 654, Vol. 238 (31 December 1954): Observations on the Cytology and Taxonomy of the Pteridophyte Flora of Ceylon. By Irene Manton and W. A. Sledge. Pp. 127–186+plates 3–14. 40*s*. No. 655, Vol. 238 (31 December 1954): Sensitivity to Light and the Reactions to Changes in Light Intensity of the Echinoid *Diadema antillarum* Philippi. By N. Milliott. Pp. 187–220+plates 15 and 16. 14*s*. (London: Royal Society, 1954.) [31

Observations Made at the Royal Observatory, Greenwich, in the year 1939, in Astronomy, Magnetism and Meteorology, under the direction of Sir H. Spencer Jones. Pp. vii+405+12 plates. (London: H.M. Stationery Office, 1953.) 90*s*. net. [31

Building Research Station Digest. No. 72: Questions and Answers, with further Notes on Emulsion Paints. Pp. 4. (London: H.M. Stationery Office, 1954.) 3*d*. net. [71

Electricity for Industry: Evidence on the Working of the Electricity Supply Industry, 26 October 1954. Pp. 10. (London: Federation of British Industries, 1954.) 1*s*. [71

Other Countries

Hong Kong University Fisheries Journal. No. 1 (December 1954). Pp. iv+65+12 plates. (Hong Kong: Hong Kong University Press, 1954.) [3112

Canada. Department of Northern Affairs and National Resources. National Museum of Canada. Bulletin No. 132: Annual Report of the National Museum of Canada for the fiscal year 1952–53. Pp. iv+313 (18 plates). (Ottawa: Queen's Printer, 1954.) 1.50 dollars. [3112

English Version of Introduction and Remarks from the Fifth Supplement to the First Edition of the General Catalogue of Variable Stars (by B. V. Kukarkin, P. P. Parenago, Yu. I. Efremov and P. N. Kholopov, Moscow, 1953), containing information about 70 Variable Stars which were newly named during 1953, and also more precise information about 324 previously named Variable Stars; and from the Sixth Supplement to the First Edition of the General Catalogue of Variable Stars (by B. V. Kukarkin, P. P. Parenago, Yu. I. Efremow and P. N. Kholopov, Moscow, 1954), containing information about 285 Variable Stars which were newly named during 1954, and also more precise information about 343 previously named Variable Stars. Pp. 35. (Leiden: International Astronomical Union, 1954.) [3112

Federation of Malaya. Annual Report of the Department of Agriculture for the year 1953. By O. J. Voeicker. Pp. viii+60+5 plates. (Kuala Lumpur: Government Printer, 1954.) 2 dollars; 4*s*. 8*d*. [3112

New Zealand Forest Service. Annual Report of the Director of Forestry—1 April 1953 to 31 March 1954. Pp. 99. (Wellington: Government Printer, 1954.) [3112

Centro Brasileiro de Pesquisas Fisicas. Notas de Fisica No. 15: Quantum Theory of the Emission Process. By Guido Beck. Pp. 13. Notas de Fisica No. 17: The Harmonic Mean Energy for Photon Absorption by Nuclei. By J. Goldemberg and J. Leite Lopes. Pp. 4. (Rio de Janeiro: Centro Brasileiro de Pesquisas Fisicas, 1954.) [3112

Nyasaland Protectorate. Annual Report of the Geological Survey Department for the year ended 31st December, 1953. Pp. 26. (Zomba: Government Printer, 1954.) [31

Chicago Natural History Museum. Fieldiana: Botany. Vol. 29, No. 1: Revision of the Genus Cheirosendron Nutt. Ex Seem., for the Hawaiian Islands. By Earl Edward Sherff. Pp. 45. (Publication 739.) (Chicago: Chicago Natural History Museum, 1954.) 75 cents. [31

Fiskeridirektoratets Skrifter. Serie Havundersøkelser. (Reports on Norwegian Fishery and Marine Investigations.) Vol. 11, No. 2: Undersøkelser over torsken i Oslofjorden. Av Finn Otterbech. Pp. 17. (Bergen: A. s. John Greigs Boktrykkeri, 1954.) [31

Annals of the New York Academy of Sciences. Vol. 58, Art. 7: Tissue Culture Technique in Pharmacology. By C. M. Pomerat, Elmer L. Sevringhaus and 48 other Authors. Pp. 971–1326. Vol. 59, Art. 2: Paul Ehrlich Centennial. By Robert J. Schnitzer, E. Grunberg and 11 other Authors. (New York: New York Academy of Sciences, 1954.) [31

l'Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture. (I.R.S.I.A.) Comptes Rendus de Recherches. No. 13 (December 1954): Travaux du Comité pour l'Étude des Maladies et de l'Alimentation du Bétail. Pathogenese, Diagnose en Behandeling van de Trichomonas-infektie bij Runderen. Door Dr. M. Vandeplassche, Dr. A. Florent, Dr. F. Paredis, and Dr. E. Brone. (Bruxelles: l'Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture, 1954.) 80 francs. [31

Flora of Egypt. Vol. 3: Angiosperme, part Monocotyledones: Liliaceae—Musaceae. By Dr. Vivi Tackholm and Mohammed Drar. (Bulletin of the Faculty of Science No. 30.) Pp. xiii+644. (Cairo: Cairo University Press, 1954.) [31

International Journal of Abstracts on Statistical Methods in Industry. Vol. 1, No. 1 (1954). Pp. viii+39. Annual subscription (3 issues) 9.50 guilders; 18*s*.; 2.50 dollars. Single issues 3.80 guilders; 7*s*. 3*d*.; 1 dollar. (The Hague: International Statistical Institute, 1954.) [71

Smithsonian Miscellaneous Collections. Vol. 123, No. 4: Revision of the Flea Genus Peromyscopsylla. By Phyllis T. Johnson and Robert Traub. (Publication 4178.) Pp. ii+68. (Washington, D.C.: Smithsonian Institution, 1954.) [71

Catalogues

A. Gallenkamp and Co., Ltd. Revised Price List and Addenda for 12th Edition Catalogue. Vol. 1: General Section. Pp. 162. (London: A. Gallenkamp and Co., Ltd., 1954.)

W. Watson and Sons, Ltd. Metallurgical Microscopes. Pp. 14. (London: W. Watson and Sons, Ltd., 1954.)

Cambridge Instrument Company, Ltd. Sheet No. 321: Cambridge Electronic Recorder. Pp. 4. (London and Cambridge: Cambridge Instrument Company, Ltd., 1954.)

Solus-Schall Limited. Leaflet No. 31: Magnetic Wall Thickness Gauge. Pp. 4. (London: Solus-Schall, Ltd., 1954.)

Rocke International, Ltd. "Short Catalog" (Brüel and Kjaer, Denmark). Instruments for Electrical, Acoustical, Radioactive, Vibrational, Strain Gauge, Electro Chemical Measurements. Pp. 14. (London: Rocke International, Ltd., 1954.)

The American Library. Recent Additions. Pp. 36. (London: American Library, 41 Grosvenor Square, 1954.)

Henry Wiggin and Co., Ltd. Data Sheet—Monel. Pp. 3. (London: Henry Wiggin and Co., Ltd., 1954.)

Hilger and Watts, Ltd. Polarimeters. (CH 242/7.) Pp. 12. Recording X-ray Diffractometer. (CH 322/3.) Pp. 12. Three-Metre Grating Polychromator with Direct Photoelectric Recording of Spectrum Line Intensity. (CH 385.) Pp. 9+3 plates. Accessories for Infra Red Spectrophotometry. (CH 388/R.) Pp. 5+2 plates. Arc and Spark Stands and Source Units for Spectrochemical Analysis. (CH 387.) Pp. 11+4 plates. New Hilger Spekker Photoelectric Fluorimeter. (Ch 390.) Pp. 4. Hilger Inspection Enlargers. (CT 430/2.) Pp. 10. Hilger Production Projectors for Routine Inspection and for Filing Gauges. (CT 420/4.) Pp. 12. (London: Hilger and Watts, Ltd., 1954.)